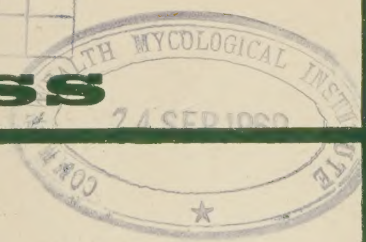
COMPLIMENTARY

EXPERIMENTAL HUSBANDRY FARMS

EXPERIMENTAL HORTICULTURE STATIONS



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MINISTRY OF
AGRICULTURE, FISHERIES AND FOOD

NATIONAL AGRICULTURAL ADVISORY SERVICE

Experimental Husbandry Farms and Experimental Horticulture Stations

SEVENTH PROGRESS REPORT

LONDON
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Introduction

This is the seventh Progress Report on experimental work at the N.A.A.S. Experimental Husbandry Farms and Horticulture Stations.

The Report does not attempt to review the whole field of investigations in progress in any one year but presents a selection of topics of particular interest, either because they are new to the experimental programme or because they have reached a stage where conclusions of practical importance can be reported.

For a fuller account of experiments being undertaken, other publications are available. Each centre prepares an Annual Report written mainly for the farmer and horticulturist, which can be obtained from the Director concerned (address on pp. 72–74). In addition, at the conclusion of most experiments the results are reported in *Experimental Husbandry*, *Experimental Horticulture* or other scientific or technical journals.

Results from Recent Experiments

CROSS-BRED BEEF: A COMPARISON OF THE PROGENY OF PERFORMANCE-TESTED BULLS

A. L. Francis*, *Rosemaund Experimental Husbandry Farm*

An article in the 1963 Progress Report described the initial phase of a combined performance and progeny test of beef bulls to see how far the growth pattern of pedigree Hereford sires was repeated in their crossbred offspring out of Friesian-type dams. The second phase, the test on the progeny, is now complete. The test was restricted to steer calves bred in the West Midlands; half of each sire group of ten to fourteen calves was reared and fattened at Rosemaund in Herefordshire and the other half at High Mowthorpe in Yorkshire.

Selection, Management and Records

After completing the performance test in each of four years the ten Hereford sires stood during January and February at Bromsgrove, Gloucester or Welshpool Cattle Breeding Centres and were used to artificially inseminate cows of Friesian-type. In-calf dams were approved by Livestock Advisers during the summer and their owners contacted near calving time. Calves were rejected on sex, physical abnormality or ill-health only and allocated to either Husbandry Farm at random. A sample check on parentage in the first year did not reveal any inconsistencies. Calves were brought directly to Rosemaund from the breeders farm when four to ten days old.

Accommodation throughout was similar for all calves. For five months individual pens were used, thereafter yards or pens with animals of similar size and individual feeding yokes; each pen at Rosemaund held five animals. All reasonable effort was made to provide a similar environment and to obviate bullying; all concentrate and most silage was fed in the yokes, but hay could only be rationed on a pen basis. The commercial context was that of autumn born calves, artifically reared, abruptly weaned when six weeks old, spending the summer at grass and coming in for fattening during their second winter. They were sold at 16 to 20 months, weighing $8\frac{3}{4}$ cwt alive and usually giving a 540 lb carcass; this experiment has thus given indirect guidance on producing the type of beef currently in wide demand. Following glucose on arrival, milk substitute was introduced within 48 hours, and hay and concentrate pellets from three weeks; concentrates were made freely available until daily consumption reached 6 lb and hay was fed *ad lib* while in individual pens. From five months the hay was restricted and silage introduced, while the concentrates were reduced prior to turning out. Throughout the summer the animals at Rosemaund were given 3 lb of concentrate daily and hay or sometimes silage if kept in the yards overnight. At High Mowthorpe concentrate was fed in 1960 but not thereafter, the calves staying out all the time to rotationally graze ryegrass/white clover leys that received up to 200 units of nitrogen per acre. Concentrate at 3 lb per

*Now at Bridget's E.H.F.

TABLE I

Financial input/output data of 18 month Hereford × Friesian beef at Rosemaund 1959–62
(Average of 230 calves reared in four intakes. Casualties excluded)

	Input	£	s.	Output	£	s.
Purchase	One calf 106 lb at six days	21	15			
0–6 months	Milk substitute—$\frac{1}{3}$ cwt at 54*s.*		18	Liveweight gain 302 lb in 176 days		
	Concentrate —7 cwt at 33*s.*	11	13			
	Hay —$3\frac{1}{2}$ cwt at 8*s.*	1	8			
	Silage —$4\frac{1}{2}$ cwt at 3*s.*		13			
	dehorning, castration, husk and blackleg vaccines	2	15			
6–12 months	Concentrate —$4\frac{1}{2}$ cwt at 24*s.*	5	2	Liveweight gain 236 lb in 158 days		
	Hay —7 cwt at 8*s.*	2	16			
	$\frac{1}{3}$ acre Pasture at 72*s.* (fertilizer, harrowing and topping)	1	4			
	Worm drench		3			
12–18 months	Concentrate —$11\frac{1}{2}$ cwt at 24*s.*	13	16	Liveweight gain 344 lb in 161 days		
	Hay —10 cwt at 8*s.*	4	0			
	Silage —36 cwt at 3*s.*	5	8			
	Warble fly dressing		2			
Return	Margin	15	10	Cold carcase weight 541 lb at 2*s.* $10\frac{1}{2}$*d.*	77	18
				Calf subsidy	9	5
		87	3		87	3

head per day was re-introduced in July or August and fed until yarding, which took place in early October at both centres. Feed then rose to 8 lb per head of concentrate, 7 lb of hay overnight and 20 lb of silage, which rose to 30 lb by the end of the winter. All animals were fed the same amount regardless of age or condition, which gave the smaller or younger animals a better chance to grow, but on these limited rations the progeny could not express their full growth potential.

Records

Exhaustive records were kept of live weight, of food consumption while individually housed, and of bodily measurement while the animals were also evaluated as yearling stores and as finished live animals. The studies continued through slaughter to appraisal of the carcass, together with carcass measurements and even in a few selected cases to cooking and tasting tests upon the final joints.

Table 1 shows the financial input/output data for the 230 calves reared in the four intakes at Rosemaund on the system described above. The effect of different prices can be seen by substitution in this table.

The Results of this Test

Since weight largely determines the financial return from beef this was the principle factor studied. There was wide variation between the performance of individuals within a sire group, between sire groups at one centre and between the performance of the same sire group at different centres. Preliminary studies soon showed that a really accurate estimate of the relation of sire performance to progeny performance would require more progeny by each sire than it was possible to accommodate, so the trial had to continue with groups of only five to seven progeny per sire at each farm. Twenty per cent variation was typical, while in every case the 'worst' sire had individual progeny that were better than some animals by the 'best' sire—defining 'best' and 'worst' by the mean value of overall liveweight gain for the sire group. Nor could all the variation in liveweight gain be attributed to the effect of the sire, since half the potential must have come from the dam. The animals on these trials were all autumn-born over a period of at least one to two months. There were indications that the animals born early in the autumn grew better throughout the winter than those born later on. However, during the second winter the reverse occurred: the earlier born ones made the poorer gains. This meant that it was possible to make valid comparisons between the progeny groups only in terms of overall liveweight gains between birth and slaughter. Comparisons within the first winter, the summer and the second winter would have been far too inaccurate. Calves with a heavier birth-weight grew better irrespective of sire. There was variation in appetite between individual animals; even if this is attributed to the sire, the animal with a bigger appetite has more potential energy to convert into liveweight.

The data provided by the individual feeding period from start to five months, when the feeding was *ad lib*, showed that most of the variation in liveweight gain that did occur between groups was accounted for by differences in food intake. In the 1960 and 1961 progeny rears, with animals of similar date of birth the liveweight gain increased by 0·4 lb for each extra

pound of starch equivalent eaten. The 1962 rear had a greater spread of birth date which influenced this generalization. For this rear, study of the two oldest and the two youngest animals in each sire group showed that the efficiency of food conversion was lower for the younger animals: the starch equivalent required for a pound of liveweight gain rose from 2·13 lb to 2·27 lb at Rosemaund, and from 2·31 lb to 2·59 lb at High Mowthorpe. All the progeny were slaughtered at a fixed live weight. The killing out percentage was associated with the age of the animal at slaughter, the data suggesting that killing out percentage would increase by about 0·2 per cent for every ten days of age at slaughter. Variation in killing out was small in comparison to that of liveweight gain, so any effect on carcass weight was largely due to the variation in liveweight gain.

In general it is probable that between ten and forty per cent of the variation in liveweight gain of sires would be passed on to their progeny. Table 2 shows that there was a tendency for the better performing sires to pass this

TABLE 2

Sire and progeny performance in ascending order of sire performance
Liveweight gains in lb per day

1959 (9 Sires)		1960 (10 Sires)		1961 (10 Sires)		1962 (10 Sires)	
Sire	Average of progeny	Sire	Average of progeny	Sire	Average of progeny	Sire	Average of progeny
2·53	1·57	2·33	1·72	2·28	1·76	2·27	1·70
2·57	1·64	2·38	1·72	2·37	1·76	2·40	1·72
2·70	1·72	2·43	1·78	2·39	1·76	2·41	1·71
2·70	1·76	2·43	1·70	2·42	1·77	2·51	1·76
2·73	1·80	2·52	1·88	2·50	1·83	2·54	1·78
2·80	1·72	2·54	1·86	2·51	1·74	2·58	1·81
2·85	1·75	2·54	1·82	2·55	1·80	2·72	1·79
2·86	1·68	2·56	1·86	2·60	1·86	2·73	1·75
3·08	1·80	2·58	1·78	2·81	1·87	2·85	1·75
		2·71	1·72	2·85	1·86	3·01	1·84

capacity on to their offspring. However, under the conditions of this experiment, the magnitude of the differences between the progeny averages was not great and the trend was not entirely consistent. From Table 3 an assessment can be made of the improvement in the liveweight gain of the crossbred progeny that would have resulted if bulls had been selected on the results of their performance tests.

TABLE 3

The effect on progeny performance of selection on sire performance
Average liveweight gain of progeny in lb per day

Within each season:	1959	1960	1961	1962	4 year average
3 worst sires	1·64	1·74	1·76	1·71	1·71
3 to 4 intermediate sires	1·76	1·81	1·78	1·78	1·78
3 best sires	1·74	1·79	1·86	1·78	1·79
Best + intermediate sires	1·75	1·80	1·82	1·78	1·79
All sires	1·72	1·79	1·80	1·76	1·77

On average, discarding the three worst sires out of each group of nine to ten would have increased the average rate of liveweight gain by only 0·02 lb per day, or less than two per cent. If only the three best sires were selected, i.e., also discarding the three to four intermediate ones, no further improvement in progeny performance would have followed.

This exercise has suggested that on the basis of a performance test, selection within a group of well-bred bulls of the same breed may give only a small improvement in the cross-bred progeny. In order to assess the heritability of liveweight gain in future investigations of this type, it may be worthwhile to test a wider range of bulls in order to establish the full extent of possible inherited variation, and to work with larger groups of progeny than the 10 to 14 compared in this trial. Special attention also needs to be directed to minimizing variation resulting from differences in date of birth of the progeny.

FARM UNITS ON EXPERIMENTAL HUSBANDRY FARMS—AN EVALUATION

M. V. Jackson, *Drayton Experimental Husbandry Farm*

Farm units have formed part of the programme at Experimental Husbandry Farms for a number of years now and it is opportune to pause and make a preliminary assessment of their contribution.

In the first place, some explanation is needed of the meaning of the term 'farm unit'. A farm unit experiment is normally one in which treatments are compared, not on a number of small plots but on very small, self-contained farms, one main treatment being applied to one farm. These farms may be from perhaps 5 acres upwards, few being bigger than 50 acres.

The farm unit experiment, as described in this article, first made its appearance at Ruakura in New Zealand where Dr. C. P. McMeekan and his colleagues have made a particular study of the inter-relationship of grass and the grazing animal. To the livestock farmer, grass is a raw material which has no cash value until it is 'processed' into meat, milk or wool. The utilization of grass *in situ* by the grazing animal presents the experimenter with innumerable problems of recording and assessment. Techniques such as those using 'tracer' chemicals to assess intake of grazed grass are a help but they are far from perfect. How, for example, are the effects of nitrogen on grass to be assessed in the context of the dairy farmer or the intensive sheep grazier? Cutting the grass and weighing it gives no idea of its feeding value to the animal. Chemical analysis is at best only a guide. A small number of cattle or sheep grazing small plots during the normal grazing season gives only a partial answer because no account is taken of the grass, or the animals, in the winter. The only satisfactory way is to keep a number of animals on a given area of land for the whole year round and to measure the output in terms of livestock products under practical farming conditions.

Thus farm units are particularly applicable to studies involving the grazing animal.

Farm units could be used for other studies such as those involving cropping, but in the majority of these cases valid results can be obtained from more conventional experiments, using far fewer resources. It seems clear, therefore, that there is a place for both the conventional small plot experiment and the farm unit. In many ways they are complementary. Some problems revealed in the course of a farm unit experiment, or indeed in general farming, can be studied in detail on small plots or with smaller numbers of animals. Alternatively, the results of a number of conventional experiments can be combined to form the basis of a farm unit trial, and this is the position with the trials on Experimental Husbandry Farms. At Bridget's and Drayton, for example, the trials involve different levels of nitrogen. Previous experiments have indicated the sort of responses to be expected in terms of yield of dry matter and this information helped to determine an appropriate stocking rate to use at each level. Information from other grazing experiments has also helped in determination of stocking rates and in suitable method of grazing, e.g., rotational grazing, forward creep

grazing etc. Results from conservation experiments have been used to indicate an appropriate method of conservation for each trial, and so on.

A number of factors have, therefore, been combined in each case to produce the farm unit experiment, and there follows a brief outline of the experiments at each of the Experimental Husbandry Farms concerned.

Drayton

A trial was started in 1960 with the object of comparing the outputs from three small all-grass 'farms' each using a different level of nitrogen. It has also been used to study the techniques involved in farm unit trials. The farms were stocked with what were considered appropriate numbers of beef cattle and sheep and the levels of nitrogen were nil (N_0), 80 (N_1) and 160 (N_2) units per acre per year. A basal dressing of phosphate is given as required. The sheep spend the whole of their useful lives in their own farm unit, the bullocks enter in spring as yearlings and are sold fat at 18 to 24 months. Each farm unit is expected to provide all the grazing and all the winter fodder needed for its complement of stock. A small amount of concentrate is 'bought in'.

It was clear from the start that this would be a fairly long-term study and substantial fences had to be erected. Each farm unit occupies 21½ acres but each is not within a ring fence. Because of the total area involved in the experiment, four fields had to be used. In order to overcome the soil and other topographical differences between the fields, each farm unit was subdivided, part of it being laid down in each field.

The stocking rates used in the earlier years have been modified with increasing experience. Considerable changes have also taken place in the swards, with the clover increasing on the 'no-nitrogen' (N_0) farm unit and decreasing on the 160 units (N_2) farm. The contribution of the clover in the N_0 farm unit did not make itself felt for at least two years.

In the formative years, using the techniques of more conventional experiments, management decisions were made to a rigid timetable, e.g., conservation, or nitrogen applications, or stock movements were carried out on the same day on each farm unit. It was soon found that to get the best out of each farm unit they must be managed as separate entities, allowing day to day decisions to be made by the manager.

For these reasons it was not until 1963 that unbiased results were expected. However, because of the extremely bad weather during the period in which the major conservation cuts were taken that year, all the hay from N_0 and some of hay from N_2 was lost. Some data were obtained, but the true comparison between the three treatments that year was considerably marred. This loss of hay occurred in spite of the fact that barn drying is used, in order to remove the variation due to weather as much as possible.

The total outputs are, as expected, mainly a reflection of stocking rate. Because of the relatively poor performance of the N_2 bullocks at grass in 1963 and the fact that this farm unit also ran out of hay early in the winter the stocking rate was subsequently reduced. At the same time, on the N_0 unit, the clover was seen to be making a greater contribution and for 1964 and 1965 the stocking rate on that farm unit was increased.

Results

Physical data

Stocking rate (number of animals in each farm unit)

Level of N	1963		1964		1965	
	Bullocks	Ewes	Bullocks	Ewes	Bullocks	Ewes
Nil (N_0)	6	18	8	24	8	24
80 (N_1)	10	30	10	30	10	30
160 (N_2)	14	42	12	36	12	36

Wool and lamb (all weights in lb)

Level of N	Wt. of wool sold			Liveweight gain* per ac as lamb			Percentage sold fat		
	1963	1964	1965	1963	1964	1965	1963	1964	1965
Nil (N_0)	118	158	137	117	140	131	100	98	97
80 (N_1)	174	185	173	160	173	158	79	87	73
160 (N_2)	260	219	232	232	196	181	47	78	94

*This figure is the total liveweight gain per farm unit as lamb divided by 21·5. Some of these acres were cut for hay and the bullocks grazed them all as well. Lambs not sold fat are sold as stores in the early autumn.

Bullocks (all weights in lb)

Level of N	Liveweight gain per ac at grass			Total liveweight gain per ac at grass and in yards		
	1963	1964	1965	1963	1964	1965
Nil (N_0)	100	111	164	134	148	NA
80 (N_1)	145	152	179	217	190	NA
160 (N_2)	135	165	217	313	221	NA

The figures for liveweight gain per acre are derived, as for the lambs, from the total liveweight gain per farm unit divided by 21·5.

NA = Not available

It is hoped that small errors in assessing the correct stocking rate will be buffered to some extent by either having a small surplus of hay at the end of each year or having to 'buy in' small quantities. No one stocking rate can be the precise optimum for each treatment every year.

In addition to the foregoing results a financial statement was also prepared but, for reasons of space, this is not presented in full. Because of the over-stocking on N_2 in 1963, and because of the loss of hay that year, only the statement for the financial year 1964–65 is considered.

Costs and returns (£ per acre)

Level of N	Total sales	Gross output	Variable costs	Gross margin
Nil (N_0)	50·2	27·2	2·1	25·1
80 (N_1)	60·3	30·7	5·4	25·3
160 (N_2)	70·1	35·5	8·4	28·1

Total sales = Sales of beef, lamb, wool, cull and casualty ewes and hay.
Gross output = (Total sales + closing valuation)—(purchases + opening valuation and ram charges).
Variable costs = Nitrogen fertilizer, concentrate, vet., drugs, sheep sprays and baler twine.
Gross margin = Gross output — variable costs.

This gross margin is slightly inflated because the costs of seeds, phosphatic fertilizer, fencing and watering, which are the same for all three farm units have been left out of the calculations above. However, these costs must ultimately be deducted along with labour, rent, machinery and other fixed costs to obtain a net profit figure. Although labour and machinery are formally fixed costs they are clearly greater with higher levels of nitrogen and increased numbers of stock.

These financial results might suggest that 80 units of nitrogen does no more than equal the contribution by the clover on the N_0 farm unit, although the physical data do show a response to 80 units N. The financial results also indicate that the response to 160 units N is not as great as might be expected. On N_2 farm, the physical data show a 50 per cent increase in output in terms of beef, rather less in terms of lamb and wool. The relatively poor financial return on N_2 was due to a lower proportion of lambs being sold fat on N_0, resulting in only 25 per cent greater return on all lambs sold. In addition, there was a higher input of concentrate and, thirdly, £114 was spent on nitrogen fertilizer on N_2, while no nitrogen fertilizer was purchased for N_0. There was also a slightly higher proportion of ewes replaced on N_2 than on N_0. It is felt that the financial statement for 1965–66 will show an improvement in N_2, as management has been tending to improve all the time.

Bridget's

In autumn 1962 three farm units were laid down. Each covered approximately 14 acres and the treatment superimposed upon them were three nitrogen levels and the number of ewes thought to be appropriate to each level. The object was to examine the problems of fat lamb production and its profitability on the simulated all-grass farm and to see how far stocking rates could be increased by increased nitrogen usage.

The levels of nitrogen and the stocking rates are given below:

Nitrogen units/ac/year	No. of ewes per ac 1963	1964	1965
50	3	3	3·8
150	4	4	4·9
250	6	5	5·4

Basal dressings of P and K are given as appropriate.

As at Drayton the stocking rates have been varied from year to year. Each farm unit was originally divided into two equal parts, a creep grazing area and a 'reserve' area. The former is used for spring and summer grazing and the latter for the main conservation cut and aftermath grazing. The reserve area can also be used when there is a shortage of grass in the grazing paddocks and, in winter, the ewes are penned on one quarter of it. If the sheep cannot keep pace with the grass on the grazing paddocks then one or more may be shut up for conservation.

There are six grazing paddocks per farm unit and the ewes and lambs circulate round them, the lambs being allowed to creep forward. Paddocks are topped when necessary.

There is a routine vaccination and anthelmintic dosing programme.

Results

Physical data

Wool and lamb (all weights in lb)

Level of N	Wt. of wool sold			Liveweight gain per ac as lamb			Percentage of lambs in Grades Q* A and B		
	1963	1964	1965	1963	1964	1965	1963	1964	1965
50	174	233	274	320	309	375	91	86	96
150	208	268	302	439	396	460	88	82	100
250	337	363	345	613	557	613	87	94	95

*1965 only. Premium of 1*d.*/lb d.w. over Grade A.

The effect of stocking rate is clearly shown in outputs of both wool and lamb. In 1963 liveweight gains of individual lambs (not shown here) and gradings fell off with increased nitrogen and stocking rate. However, the spring was a late one in that year and it was the first harvest year of the ley (undersown in 1962) which was thin and open after the harsh winter. It was decided to reduce the stocking rate at the highest level of nitrogen for the following year.

In 1964, lambs at the highest level of nitrogen and stocking rate graded better than the others. Liveweight gain of individual lambs on this treatment was as good as that of individual lambs on the least intensive treatment. It became apparent that the 50 : 50 ratio between grazing area and reserve (conservation) area was not the optimum. Excessive amounts of winter feed were being conserved and so one acre was cut off each reserve area. This increased the effective stocking rates and further adjustment to these was also made for 1965.

At the start of the experiment it was decided, in order to control worms, that while on the creep grazing area the ewes would spend four days on each paddock, i.e., taking 24 days to complete a circuit of six paddocks. During 1963 and 1964 this was adhered to, but it was found that in periods of vigorous growth four days was not sufficient for the sheep to graze down a paddock and this adversely affected the grass. Since drugs, rather than the grazing cycle, were being relied upon for worm control, longer grazing of h paddock would be possible. So, in 1965 this timing was abandoned,

the ewes being moved forward when each paddock was properly cleared up, and this proved very successful. Nematodirus is present on all farm units but is being kept in control. Coccidia have caused concern.

The breed of ram, previously Clun, was changed to Dorset Down for 1965 in an attempt to produce quicker-growing lambs.

Costs and returns

Level of N	Total return			Gross output			Variable costs			Gross margin		
	1963	1964	1965	1963	1964	1965	1963	1964	1965	1963	1964	1965
50	30·2	29·7	36·1	21·7	21·9	29·3	11·9	11·6	12·3	9·8	10·3	17·0
150	38·0	37·4	44·8	29·3	27·0	34·4	16·6	15·9	18·0	12·7	11·1	16·4
250	53·9	52·2	55·5	42·4	43·0	40·8	23·6	21·0	22·2	18·8	22·0	18·6

Total returns = Sale of lambs, cull ewes and wool.
Gross output = Total returns minus cost of ewe replacements and ram charges.
Variable costs = Fencing and watering equipment, grass seed costs, fertilizers, baler twine, concentrates, medicines and rented keep (1963 only for the most intensive farm unit).
Gross margin = Gross output minus variable costs.

Gross margins have increased with increasing nitrogen usage and higher stocking rates.

At this stage an interesting practical point emerges. If the financial results from Drayton are referred to again it will be seen that there was virtually no difference in gross margin between 0 and 80 units of nitrogen and very little between these and 160 units. This trend is repeated at Bridget's, with very little difference between 50 and 150 units (near, but not quite analagous to 80 and 160 units). It seems as though it is only when really high nitrogen usage is practised that there is a worthwhile extra margin.

Great House

The object of the trial on this farm which began in the spring of 1963, is to compare the relative productivity of permanent grass and temporary grass. The two farm units, each of $41\frac{3}{4}$ adjusted acres were stocked with flying herds of Ayrshire cows for milk production. As at Drayton and Bridget's, care was taken to minimize soil and topographical effects between treatments. The two farm units share a common farmstead where both herds are milked. These herds started as matched groups of 21 cows but the numbers have subsequently varied independently according to available grass or conserved fodder.

Apart from differences in sward type and the way in which these affect cow numbers, conservation, concentrate usage, labour and machinery costs, etc., both farm units are subjected to the same management; they also share equally such items as rent, rates, telephone, electricity and depreciation on milking machines.

The same cowman and assistant serve both farm units exclusively, with occasional help from one part-time worker and relief milkers as necessary. Labour and machinery from Great House are used for conservation, carting farmyard manure etc., and are costed on a contract basis.

Fertilizer usage on both farm units is the same at 180 units of N per acre per year with 50 units P_2O_5 on the grazing land and 180 units K_2O on the mowing land.

Records of output and costs for each farm are kept separately and the results for the first two years are summarized briefly below.

Results

Sales of milk, stock agisted on the unit and work done elsewhere

	1963–64		1964–65	
	Temporary farm	Permanent farm	Temporary farm	Permanent farm
Milk (gal)	18,042	16,980	16,478	15,340
Agisted grazing:				
Sheep days	4,175	4,175	4,278	4,734
Heifer days	611	nil	nil	nil
Work done away (man hr)	160	158	106	108

Output also includes sales of cows and calves adjusted for valuation and purchases. Costs include concentrates, bought-in hay, fertilizer, labour, ley depreciation, rent, machinery, etc., etc.

All figures in £

	1963–64		1964-65	
	Temp.	Perm.	Temp.	Perm.
Output	2,691	2,593	2,704	2,528
Costs	2,304	2,010	2,386	2,249
Management and investment income	387	583	317	279

In both years there was a greater milk output from temporary grass than from permanent grass, due to a higher yield per cow and better milk production off grass in spring and summer. This is attributed mainly to the stimulus from maiden seeds ($\frac{1}{5}$ of the temporary grass farm is re-seeded each year). The advantage to the temporary farm in summer is slightly offset by higher concentrate cost in winter due to the conservation area on this farm being reduced when land is ploughed up for re-seeding.

In the first year a cow died from hypomagnesaemia on the temporary grass farm and this resulted in a marked advantage, in sales of cows and calves, to the permanent grass farm. Also in this year eight acres of hay on the temporary grass farm was completely spoiled by the weather and the bulk of the winter requirements for this farm had to be bought in. With no such accidents in the second year, coupled with the fact that more milk was produced on the temporary grass farm for a relatively lower concentrate cost per gallon, this farm showed the greater profit.

General Discussion

There are many obvious similarities and some differences between each Farm's approach to the farm unit experiment. In the first place most are aimed at studying the output of animal products from grass receiving moderate to high levels of nitrogen. Results have been expressed in financial as well as physical terms. It is clear that these results are influenced by the stocking rates chosen, by management decisions and by the season. At all centres basal dressings of phosphate and potash fertilizer or phosphate alone (Drayton) are applied uniformly over each treatment.

The most striking difference between the three Farms is that of the size of the units, from 14 acres at Bridget's to over 40 acres at Great House. Because of the greater size at Great House it was possible to allocate two men exclusively to the trial. This has obvious advantages in apportioning labour costs.

There are different classes of stock at different Farms—dairy cows at Great House, sheep at Bridget's and beef cattle and sheep at Drayton. These beef cattle spend only the last year of their life in the experiment, whereas the sheep, as at Bridget's and the dairy cows at Great House, spend the greater part of their useful working life in the farm units. At Bridget's, there is a routine dosing programme against worms while at Drayton anthelmintics are given only on specific veterinary advice. However, the sheep are kept less intensively at Drayton than at Bridget's. At Drayton the main conservation cuts are taken in rotation, from different paddocks in succeeding years, but at Bridget's and Great House the main conservation areas are entirely separate from the grazing areas. This is a matter of necessity at Great House, due to the topography, and at Bridget's because of all the fencing needed for the grazing paddocks.

A considerable body of knowledge and some expertise have been accumulated during the course of these farm unit experiments but there are still many unanswered questions concerning their conduct. The following are some examples of this type of question, which have arisen at the farms under discussion.

Sometimes, due to bad weather, all or part of the hay crop from one farm unit is lost but that from the other unit(s) is harvested successfully. This need not be a treatment effect but it exerts a profound influence on a whole year's results.

In an all grass (permanent pasture or long term ley) farm unit system perennial weeds such as nettles and thistles can become a nuisance, in spite of the use of herbicides. On a commercial farm a badly infested field could be ploughed up and re-seeded but this is not possible in a semi-permanent farm unit. This has been overcome on the temporary grass unit at Great House by ploughing up a proportion of the unit each year. The preceding argument also applies to poaching during winter and is one reason why, at Drayton, all the ewes are wintered indoors.

Running two classes of stock, as at Drayton, while having several husbandry advantages, complicates the management of the farm unit, particularly that at the highest level of nitrogen. Under more intensive grass management the use of an electric fence for controlling grazing is extremely useful but a single wire will not restrain both cattle and sheep. The frequent moving of two sorts of electric fence or the use of more permanent fences is out of the question economically.

The replacement of casualties is always a difficult problem. Very often the cause of an animal becoming a casualty is completely unrelated to treatment, on the other hand there is no doubt that some casualties are a result of the treatment. In farming practice the farmer would not replace ewe casualties until making up before tupping in autumn, but in a farm unit the loss of one ewe (and a variable number of lambs) will immediately affect the nominal stocking rate.

The use of 'blanket' dressings of phosphate and potash fertilizers in a nitrogen levels experiment is common. P and K are undoubtedly wasted or used insufficiently at one end of the scale or the other. The same applies to 'blanket' dosing for worms etc. The presence of 'a worm problem' may quite well be a treatment effect and though the blanket dose may be admirable from the experimental point of view, in reducing to a minimum all variables except the one under comparison, the result is not a true reflection of the experimental treatment. In a farm unit experiment there are so many variables involved anyway that one might be tempted to argue an extra one would make little difference.

These are some of the problems, but what has been achieved? What guidance can be given to others contemplating this type of experiment?

First, there is the over-riding effect of stocking rate. This presents a problem and the solution of having more than one stocking rate on each main treatment is not so simple in a farm unit experiment where, generally, the whole lives of animals are involved. It is easier to adopt in a 'grazing season only' experiment carried out on fairly small plots, but against this there is the problem mentioned in the introduction of what happens in autumn, winter and early spring. It may be that attempts to solve the stocking rate problem already adopted by the Farms concerned are more suitable for farm units, i.e., a subjective choice based on experience which can be altered from year to year. This implies a fairly long run of years and brings up a second major point. It is a danger inherent in any long term experiment and even more so in farm units, that in a rapidly changing economic climate, conditions when the experiment is conceived may be widely different when it ends. In such circumstances detailed annual financial results may be of doubtful reliability in the long term. There is still no substitute for accurate physical data. This basic information can always be translated into current economic figures.

A third major point, linked with stocking rate, is the general question of management. It is sometimes difficult to translate the results of straightforward manurial experiments, for example, into 'normal farming practice'. How applicable, then, are the results of a farm unit experiment in which so much of the answer depends on the skill of the manager?

So far the discussion has been critical of farm unit experiments but there is no escaping the conclusion that where grazing animals are involved the farm unit has a lot in its favour. Even with all the modern scientific knowledge nobody can say exactly how much milk a sward will produce until the cows go on and give the answer. This is particularly relevant with, for example, late autumn grass. In the case of sheep, there are problems such as the effects of winter grazing on the productivity of grass during the subsequent spring and summer. This can be examined properly only in a whole-year round study extending over several years and with reasonable numbers of sheep, and is not easily simulated on small plots.

Management problems are continually being revealed in any experiment of this nature and it may be that this is one of the greatest merits of the farm unit approach, as a means of bringing these problems to light. How they are overcome in a farm unit depends on the individual manager, but in a number of cases they can be examined more objectively by means of conventional experiments. It can be argued that management problems are continually being revealed on any commercial farm and that a farm unit is not needed to bring them out. This is true, but only in a farm unit with full experimental facilities can all the facets be studied in minute detail. Data derived from careful weighing, measuring and recording, correctly interpreted by trained personnel, will help to provide answers to these problems. Even so, it may still be difficult to pinpoint one particular reason responsible for a given result. In a farm unit, simulating as it does a whole system of farming, a result is due very often to a whole complex of factors such as level of nitrogen, stocking rate, time of application of nitrogen, movement of grazing stock, numerous management decisions and many others. In a conventional experiment, in which extraneous factors have been reduced to a minimum, one can say with a fair degree of confidence, for example, that x cwt of extra corn was produced because y cwt of nitrogen was applied. Results from farm units can seldom be as clear-cut as this.

The farm unit can be a useful tool primarily where the grazing animal is involved, but it is not going to supersede the conventional small plot or replicated experiment. Resources in land are scarce and farm units occupy relatively large acreages. They use large numbers of animals which, even so, constitute a minute proportion of the population they are supposed to represent.

One final point, related to an earlier paragraph on economic data, the farm unit experiments as described have been subjected to several changes since each began, e.g., stocking rate, relative size of areas shut for conservation, etc. These have been made as experience dictated, but taken to extremes they could result in the physical conditions during the last year of the experiment being almost totally different from those in the first. It does seem, however, that a certain amount of change is unavoidable in this type of experiment and some age-old concepts may have to suffer. Up to now farm units have reinforced existing knowledge on the importance of stocking rate, the use of nitrogen on grass and the fact that this highly manured grass does not normally have any deleterious effects on stock. This last point has been shown on small scale 'research' plots but on that scale has been unacceptable to many farmers. Farm units have indicated numerous management problems and they have proved of considerable interest when demonstrated to farmers. However, they should be used with discretion, and the possibility of obtaining a useful answer from a more conventional experiment should be explored fully before embarking on a costly farm unit.

If the aim is to investigate the problems associated with a particular system of farming, rather than necessarily finding simple answers, then the farm unit is worthy of serious consideration.

FATTENING OF STORE LAMBS

R. B. Mair, *High Mowthorpe Experimental Husbandry Farm*

The problem of what to do with the lambs which have only reached store condition when grass becomes short in autumn confronts many farmers. On the lowlands, increased stocking rates on the summer grazings often means that some lambs have failed to get fat off grass and must either be retained for winter finishing or sold at a relatively low price. On the hills, the sale of the wether lambs as stores represents a high proportion of the total farm income and in seasons when the store trade is poor, many farmers must seriously consider cashing in these lambs by some other means. In order to shed light on the problem, traditional methods of finishing have been investigated and compared with new methods at three Husbandry Farms.

The Hill Farm: Finishing on Kale, Grass, or Indoors

At Great House a flock of Derbyshire Gritstone ewes are grazed on common moorland during the summer. Traditionally, the wether lambs are sold at the autumn store sales. In years when store prices were low, the poorer quality lambs would average little more than £2 per head and selling at this figure must result in low incomes. Trials were therefore started in 1959 to assess the economics of various methods of feeding store lambs to finish in late autumn and winter.

In the early years, fattening outside on kale and on grass gave satisfactory returns when up to 1 lb per head per day of a cheap home mixed meal was fed, but indoor feeding was not so satisfactory. The indoor groups in these early trials received *ad lib* hay and a daily ration of concentrates. When this ration was only 1 lb per day results were disappointing and, with many lambs failing to reach gradable conditions, returns were low. In 1960, a group of lambs finished inside on hay and concentrates had a feed cost of 22*s.* per head and a mean carcass value of £3 19*s.*; whilst lambs finished outside realized at least £1 per head more for an average feed cost of 26*s.* 6*d.* per head. It was apparent in these early trials that higher levels of concentrates were needed for profitable indoor finishing than were required on kale or grass. This is clearly shown in a trial carried out in 1962 which gave the following results:

Total returns, food cost and margin for groups of 20 lambs

	Total return £ s.	Total food cost £ s.	Margin over food cost £ s.
Grass + ½ lb concs/day	124 12	9 2	115 10
Indoors. Hay + 1 lb concs/day	94 16	23 0	71 16
Indoors. Hay + 1½ lb concs/day	119 6	28 1	91 5

With the lambs valued in at £4 per head and including handling charges, these returns result in the grass fed group showing a margin of 33*s.* per lamb,

the indoor group receiving 1½ lb of concentrates per day a margin of 8*s.* 6*d.* per head, whilst costs exceeded returns by 11*s.* per head in the case of the indoor group receiving only 1 lb of concentrates per day.

Since 1963, trials at Great House have concentrated on comparisons of various systems of feeding concentrates *ad lib* to housed lambs. In two trials, lambs on a Rowett type mixture with no hay have produced better carcass weights than similar lambs receiving hay with '*ad lib*' concentrates. Differences in food costs have been small, so that on balance the margin over food costs has been higher where no hay was fed, but from general health considerations a small daily ration of hay is probably advisable. In a trial in 1964–5, whole barley, in a mix of 15 parts barley to 1½ parts of groundnut flake, was compared to a similar ration made up with rolled barley. The lambs on whole barley had a lower daily intake of concentrates and tended to eat more hay. They finished satisfactorily but carcass weights were lower than those achieved on rolled barley (34·8 lb as against 37·2 lb).

With lambs of 60 to 70 lb liveweight costed in at figures of £3 10*s.* or £4 per head, the high concentrate feeding systems of indoor finishing have normally left margins of around £1 per head. Obviously the value of the store lamb will have a major effect on eventual profit, but the Great House trials clearly suggest that this method of finishing does offer a way of increasing profits on hill farms when store lamb prices are low. Where grass is available the feeding of 1 lb of concentrates per day to lambs on grass has given better margins than any indoor feeding systems.

The Lowland Farm: Finishing on Roots

At High Mowthorpe, a flock of Scottish Half-bred ewes is kept and mated with Suffolk rams for fat lamb production. Lambing takes place in early April and when the ewes are stocked at over 6 per acre with their lambs during the summer a proportion of the lambs fail to go fat off grass. These have been used in experiments to compare methods of finishing by folding on forage root crops and by indoor feeding.

Mixtures of soft turnips and kale have been the crops usually used at High Mowthorpe, but recent experiments suggest that giant rape is a far more productive feed than kale for lambs. After weaning, the lambs are run on surplus grass and corn stubbles until October, when the majority are moved on to roots or housed. A trial comparing the performance of lambs on stubbles with that of lambs on a special Rape and Italian Ryegrass mixture in the September-October period, prior to both groups finishing on soft turnips and kale, showed that the lambs that had been on the special keep yielded better carcasses when finished in January. The extra return was not great enough, however, to justify devoting land to this special form of keep on a farm where stubbles, or grass land, were available. If keep is short in September and October a small daily ration of rolled barley would be more economic than devoting land to growing specialized crops.

Levels of concentrate feeding varying between ¼ and 1 lb per head per day have been compared on the turnips and kale, but there has been no consistant advantage in favour of any particular level. During good dry weather conditions the response to concentrate feeding has been small, and usually uneconomic, but in wet or unduly cold weather the response to ¾ or 1 lb of rolled barley per day has been worthwhile. The practical interpretation of

these results suggests that a small daily ration of corn should be fed to lambs on roots so that it can be quickly increased to offset the effect of bad conditions during adverse weather.

Feeding a higher level of concentrates to folded lambs resulted in only a slight increase in the stock carrying capacity of the crop, as the weather was the main factor determining when the flock needed moving to a new fold; in wet weather the feed was badly soiled before it could be eaten. On average, between 30 and 40 lambs were carried on each acre of turnips and kale, for a period of 10 to 12 weeks.

To obtain good returns per lamb, and per acre, it was essential to achieve a high proportion of finished lambs off roots. In the groups that encountered bad weather conditions or started losing their lamb teeth before they were fit, the high proportion of lambs that required further feeding before sale meant that there was little appreciation in value. The average lifeweight gain was up to 15 lb per head, for good groups, and as low as 7 lb per head for the poorest group, over the period on roots. The amount of weight put on obviously affected the returns but the main factor affecting the margin over costs was the appreciation in value between the cost per lb of store lamb at the start of feeding and the price received per lb at sale.

Under good conditions the margin over ingoing valuation and feed costs was up to £75 per acre, but fell to £10 per acre when performance was poor and the appreciation in value small. On average the margin per acre was approximately £30.

On a margin per head basis the best figure achieved was 42*s*. 6*d*., the worst 3*s*. 3*d*., and the average over 350 lambs in three seasons was 16*s*. 10*d*. This average was greatly reduced by the inclusion of some groups of lambs, on low levels of corn feeding throughout the period on roots, which did badly in poor weather conditions. It would appear from these trials that if store lambs are purchased at a price of no more than 1*s*. 6*d*. per 1 lb live weight and receive good management on roots so that they finish in late January, a margin over store lamb and food cost of at least £1 per head can be expected, under present day prices.

The Lowland Farm: Finishing Indoors

The adaption of the Rowett Barley Beef feeding system as a method of finishing store lambs quickly, has obvious advantages on a cereal growing farm, if it can be done profitably. Experiments at High Mowthorpe and Drayton show very wide variations in the level of performance, when lambs have been offered rolled barley and protein supplement to appetite. The margin over store lamb and food cost has varied from nil up to better than 25*s*. per head. This variability is rather surprising as one of the most outstanding features of this system of feed with cattle is the consistency of results. The term 'store' when applied to lambs, covers a wide range of sizes and types and the condition of the lambs at the commencement of feeding will obviously have a great effect on performance.

The best margins were achieved when the feeding period was restricted to six weeks or under and for this reason the lambs must not be too poor when '*ad lib*' feeding starts. Trying to achieve too high a degree of finish prolonged the time to slaughter, decreased the efficiency of food conversion, and reduced profit. Selling price has a profound effect on profit and, because

prices rise after the turn of the year, lambs finished in February and March left satisfactory margins. It would appear that this method of feeding provides a useful way of bringing suitable store animals to a marketable condition quickly, but will only be profitable if there is an appreciation in the price per lb during the feeding period or if it is used as a way of cashing in cheap gains made on arable by-products.

On a cereal growing farm, stubbles can be used to provide very cheap feed for store lambs during the autumn, and a small weight gain can be achieved at very little feed cost. When keep becomes short in December, if concentrates are then gradually introduced and built up, the lambs will be ready for housing on a high concentrate diet, for finishing in February and March. Using this method at High Mowthorpe has resulted in very fair margins from lambs finished indoors.

Silage has also been used for fattening lambs and can result in a saving in the amount of corn required. On *ad lib* silage, daily consumption varied between 2 and 5 lb per head and this, plus 1 lb of barley, gave good performance where the quality of silage was good and it had a high dry matter content.

On all three farms similar methods of acclimatizing the lambs to high concentrate diets have been used. Concentrates are offered before housing and generally two injections of Pulpy Kidney Vaccine are given. In one trial at High Mowthorpe the vaccine was not used before housing and trouble with clostridial-type infections was experienced. On housing, hay is offered and the daily ration of concentrates gradually built up until some is being refused; the feeding hoppers can then be introduced and the hay gradually reduced to a small daily ration or, if desired, withdrawn altogether. In one trial, at Drayton, concentrate consumption went up rather too quickly and some scouring resulted, but a reduction in concentrates followed by a gradual increase over two weeks easily corrected the trouble.

Various types of concentrates have been used, rolled barley plus a protein/mineral supplement being the most common. Other more complex mixtures have not appeared to give any worthwhile improvement in performance. On occasions, lambs may select the barley and refuse the protein pellets when they are first introduced. Where this has occurred groundnut flakes or linseed cake are more acceptable, but once the self feed hopper is introduced this trouble seems to decrease.

The lambs on this type of feeding at the farms have been healthy, and losses have been uncommon, but in all cases the buildings used have been airy with good ventilation. At Great House a stone outbarn, fitted with a slatted floor, was used; at Drayton also the lambs were on slats, but at High Mowthorpe the lambs were bedded in straw in an open fronted machinery shed. Clean water is essential.

Ad lib feeding of concentrates to store lambs at grass was compared to feeding indoors in a trial at Drayton, using Suffolk × Half-bred lambs. Both groups were offered rolled barley, plus protein and minerals, to appetite plus a small daily ration of hay. One group was housed on 23 October and the others remained out at grass. From late October to the end of November the rate of liveweight gain was similar in both groups, but the outdoor sheep were eating less of the concentrate mix. The weather was good during this period and the sheep on grass were presumably finding some grazing. In mid-December a period of bitterly cold weather resulted in the concentrate

consumption of the outside sheep increasing sharply (they ate over 5 lb per head per day for a period) whilst those indoors had a steady daily intake of around 2½ lb per day. In the period of bad weather the outside sheep failed to gain weight, so that over the whole trial there was very little difference in either the performance or the food consumption of the two groups. Conversion rates in this trial were poor and the margins over food cost were therefore small and unprofitable.

Conclusions

The trials indicate that on both upland and lowland farms there is a place for finishing store lambs on both traditional lines and by indoor feeding. Where specialized lamb feed, surplus grass or cereal stubbles are available these can be used, with appropriate cereal supplements, to give useful returns providing the lambs are away before severe winter weather sets in.

Housing and finishing on high concentrates can be a profitable system providing the period of feeding is short and the price realized per lb is higher than that given for the store lamb.

Indoor finishing would seem to offer great benefits to the upland flockmaster faced with a poor price for his store lambs. In specialized circumstances in the lowlands, where cheap by-products are available to run the lambs through the autumn, it can be used to cash in on cheap gains made on these by-products.

SYSTEMATICS RESEARCH AT THE NATIONAL FRUIT TRIALS

H. J. Gooding, *National Fruit Trials, Brogdale*

Accurate identification of the cultivars of any crop is essential if its development and progress is to be maintained. This is particularly true for the plant breeder who must know the identity of his parent material. The nomenclature of cultivars of hardy fruits and their identification has for a long time been a difficult subject and with the establishment of a systematics section at the National Fruit Trials at Brogdale modern scientific methods are now being brought to bear on it. Dr. H. J. Gooding who is in charge of this work has contributed the following article.

Systematics is the science which is concerned with studies of the diversity of organisms and the relationships among them. It covers identification, nomenclature and classification and includes taxonomy which is the study of classification. The principles and methods involved have wide application, for instance, in the classification of soils and bacteria. Methodical classification of horticultural plants means the arrangement of cultivars into groups according to the degree of similarity existing between them. It is based on the study of the range of characters which the cultivars concerned possess. Having worked out a system of classification we should be able to assign an unknown cultivar to a particular group having several characters in common. It is like a filing system which can be used to aid identification. Groups may be further divided into sub-groups. Thus within the Cox group of apples a sub-group could be formed of cultivars with stipules of a certain shape. The process of grouping focuses attention on correlations between character expressions. Characters which may have no economic importance in themselves may be associated with those of particular economic value. This knowledge can be of great use to a plant breeder in early selection when only vegetative characters are available.

At the National Fruit Trials the present systematics section, which was started in September 1963, is concerned with this type of study applied to the National Fruit Collections. The investigations are therefore aimed at characterizing the cultivars as objectively as possible, in order to devise systems of classification and so facilitate identification.

As a matter of policy it was decided initially to confine the investigations to the National Apple Collection. The principal reasons for this were the absence of any satisfactory existing classification, the economic importance of apples and the probable introduction of Plant Variety Rights for apple cultivars.

Because there are over 2,000 cultivars in the apple collection, two samples have been chosen for classification. One sample, for detailed studies, consists of 36 cultivars selected to present many of the problems likely to be encountered in the classification of the collection as a whole. The other sample of 260 cultivars includes all commonly grown commercial and garden cultivars and those representing a wide range of variability.

As there are two trees of each cultivar in the collection, all on rootstock M.VII, specimens are principally obtained from them. In order to study the

effects of other environments and rootstocks on the characters, samples are also obtained from other parts of the country.

One of the first problems is the choice and measurement of characters. This involves the study of character variability in order to select those which are most stable within cultivars and yet display large differences between cultivars. These characters are of most value for identification.

Having selected a character for investigation a method must be found to measure it as objectively as possible. An apple, for instance, presents a complex shape which can perhaps be visually appreciated but the means of accurately communicating information on it is difficult. The shape can be broken down into a series of measurements, which, when taken together, provide a numerical description but even this may not be fully adequate.

Sampling methods must also be found which are likely to give reproducible results. This involves the measurement of character variability at different sampling dates and positions. For example, the specific gravity of fruits change with their maturity. It is known that the terminal fruits (called 'King' fruit) and lateral fruits of an inflorescence often differ markedly in morphology. Stipules and leaves from spurs (short shoots) have different shapes from those of leaders (long shoots) and they vary along the length of long shoots.

Characters are probably best sampled over a range of disciplines, including physiology and chemistry, particularly as gross fruit morphology alone seems unlikely to provide sufficient information for precise identification in many cases. Fruit of different cultivars can sometimes appear identical whilst an examination of their vegetative characters will reveal clear differences. An example of this is 'Orleans Reinette' and 'Blenheim Orange'.

The reason for this seems to be that man has practised selection principally for fruit characters within a relatively narrow band of variability ignoring vegetative characters such as the size and shape of leaves and stipules. If reproductive and vegetative characters are not highly correlated, then taken together they are likely to provide a more effective means of identification.

In other cases, for instance 'Lord Lambourne' and its red fruited sport 'Lady Lambourne', only the fruit colour at full maturity shown by fruit of trees grown in the same environment display sufficient differences to suggest that genetic differences exist between the two 'cultivars'. Chemical characters might be of value as a further aid in instances like this as well as with examples of fruit differences when the morphology appears identical. 'Tower of Glamis' and 'Lord Derby' under certain conditions produce fruit which are virtually identical yet there is a marked difference in flavour.

The example of the 'Lambournes' given above emphasizes the importance of genotype/environment interaction and the need to gather information on this aspect. In order to do this samples have to be obtained from different seasons, sites and rootstocks. This obviously increases the task of classification but to ensure that most of the variability caused by the environment is incorporated in a classification, it is obligatory to know the ranges of expression of the different characters. This information increases the probability of correctness of identification.

Since most apple cultivars are generally self-incompatible, supporting evidence confirming identification could be obtained from pollen-tube growth studies. This might also increase the period of diagnosis but it may be very valuable in specific instances where the question of variety rights was at stake.

Fortunately, in the course of surveying a wide range of characters it is frequently proving possible to find one or more characters which can be readily measured or scored and are sufficiently extreme in their expression, and therefore distinctive, that they can be used to identify a cultivar. Examples of this occur with the stipules of 'Mutsu' and 'Fortune'. Usually, such characters where they are not quite sufficient for identification will reduce the numbers of cultivars to be checked to easily manageable proportions. A good deal however depends on employing a standard sampling technique to obtain the characters for comparison.

Despite the usefulness of vegetative characters as much information as possible has to be obtained from the fruit since these are usually sent for identification. The limitations this imposes are often great especially with the fruit of closely related cultivars.

With the case of fruits being sold under the wrong cultivar name it can sometimes be very difficult to pin-point a specific character of fruit morphology which can be used for positive identification because of the overlapping of character variability. On the other hand, it is often easier to say that it is not a specific cultivar because of the absence of some special characteristics or a combination of them.

With the object of determining the usefulness of fruit measurements for identification at least 25 measurements are being made on each of five lateral fruit from each of 30 cultivars and this is being repeated over three seasons. Studies on the variability of these measurements and the relationships which exist between them are being conducted in co-operation with the Statistics Section at East Malling Research Station.

The measurements, taken over all cultivars have been found to be highly correlated and related to fruit size. The diameter of the fruit 'eye' for instance tends, in general, to increase with fruit size, irrespective of cultivar. Also, because of the extensive overlapping in the ranges of the individual variates, (that is, quantities actually measured on the specimens under study) due to environmental effects, it is proving very difficult to distinguish many cultivars on these measurements alone. This is particularly the case with cultivars closely related to 'Cox's Orange Pippin' which has been so frequently employed as a parent in breeding that many cultivars are closely related to it genetically and very similar morphologically. Although individual fruits of 'Cox's Orange Pippin', 'Late Orange' and 'Superb' can often be readily identified on taking colour and shape into account this is not the case with shape alone. The stipules of 'Cox's Orange Pippin' and 'Superb', however, are generally easily distinguishable.

Where the raw data is not directly employed the characters are being coded. Fruit diameter which can vary continuously, can be broken down into steps which will allow for natural variability. It should be clear that the codes for this character will be the same for a large number of cultivars, and will therefore have very poor discriminating power. Only the extremes will show differences such as 'Gros Fenouillet des Pyrénées' with its very small fruit and 'Peasgood's Nonsuch' with extremely large fruit, but by combining together characters which individually have poor discriminating value, better differentiation can be obtained.

Clipped cards are being used for storage and retrieval of coded information, a knitting needle only being needed for sorting. Their advantage lies in permitting one to sort immediately for any prominent character in the

specimen to be identified. However, the characters must be effectively coded to be of use and this presents difficulties with certain characters which are only readily appreciated subjectively. Now that data is being put on to clipped cards we can start asking questions about the distribution of characters and possible associations between them. For instance, we can readily determine how many cultivars produce, say, russet fruits and how many of these have stipules of a particular type. We can quickly provide answers to numerous questions of this nature, answers which often cannot be found elsewhere.

The classification problems associated with small groups of cultivars usually present far fewer difficulties than the samples especially chosen for study, because it is often easier to find characters which may be treated as discontinuous within the group as their ranges may not overlap. Twelve cultivars, including mother trees of virus tested clones, have been classified using vegetative characters alone. Lamina, petiole and stipule characters have been used in an identification key. From an examination of nursery material (maidens) it appears that the present key can be modified to make identification of these relatively simple.

For large numbers of cultivars the ordinary dichotomous key is exceedingly difficult to apply successfully because of their variability. The locules ('pockets' of the core in which the seeds are found) may vary from closed to open on one fruit and differences are found in fruit of the same cultivar at varying stages of maturity. In samples of up to 40 fruits of individual cultivars a particular type tends to predominate. The distribution of character measurements, or scores, then becomes important.

Because of the limitations imposed by staffing, only a selected range of morphological characters can be studied. Also, in order to produce a classification which is workable with samples obtained from plants growing under a wide range of conditions, the characters must be sampled over a number of years. Only in this way can the ranges of variation of individual characters be fully assessed. The investigations on apple cultivars will of necessity take some years to complete but it is expected that the methods adopted will have application to the broader field of the classification of cultivated plants and in particular to other top fruits.

HERBAGE CONTROL IN DESSERT APPLE ORCHARDS

E. Gunn, *Efford Experimental Horticulture Station*

Systems of soil management in orchards have been developed over the centuries to suit the general situation of the orchard and the mechanical equipment available. At no time has there been a system common to all farms, though recently the differences have become much less as growing techniques have become more uniform.

The first planting of dessert fruit on commercial lines is attributed to Henry VIII's fruiterer, Richard Harrys, in 1533. For the next four hundred years most of the better managed orchards were cultivated mainly because there was no suitable alternative method, and some orchards were intercropped with soft fruit or vegetables. At the same time, however, there were orchards which were grassed down and either grazed or cut for hay, following very similar practices as were used in cider orchards. An indication of the management practices is obtained from a survey of the Lower Greensands in Kent in 1930, which showed that about half of the orchards were cultivated, one third of which were intercropped with soft fruit. This, however, reflected a recent increase in orchard planting as the same acreage of soft fruit interplanted in 1891 represented 36 per cent of the total orchard acreage. The remainder of the orchards in this survey was classified as 13 per cent rough grass and 36 per cent well grazed.

Since 1930 there has been a rapid increase in the number of orchards grassed down, and a corresponding decline in the number of orchards intercropped. The introduction of the gang mowers for grass cutting allowed the specialist fruit grower to keep the grass short, and so reduce the competition by the grass, without the need to keep cattle. This also fitted in with the general desire for bush trees with their easier management and spraying. Experiments at the fruit research stations demonstrated that by selecting the right sward, mowing frequently and giving adequate nitrogen fertilizer, the competition by the sward for water and nutrients could be reduced. The result has been that to-day the majority of orchards are grassed down either at planting or within the first six years.

Herbicides

Economic pressures are, however, causing fruit growers to reconsider their present orchard layout and management. The general trend is to more intensive systems using dwarfing rootstocks, in an attempt to produce smaller more manageable trees which come into cropping quickly. In general the present methods of soil management are not totally suited to these new methods, and techniques are being developed using herbicides to overcome this problem.

The present comparative costs between using herbicides and grass cutting are very similar, except in the controlling of the herbage immediately around the base of the trees where the use of weedkillers is cheaper. The need to obtain maximum cropping early in the life of a plantation means that the trees must be grown as quickly as possible to fill the allotted space. In the majority of orchards there is not enough available water for maximum

growth, experiments having clearly demonstrated that under these conditions even a very weak sward will severely check the growth of the trees, and so reduce the yield. By reducing or eliminating this competition herbicides can be of value, especially, in the early years of the plantation. The frequent mowing necessary in grass orchards also creates problems; the overall cost is not excessive, but the period of maximum mowing coincides with the peak period for spraying. This results in competition for tractor time and, as it is essential that spraying is carried out regularly, the mowing is often left at a time when competition by the sward can do the most harm. Herbicides overcome a number of these disadvantages without giving the practical objections that full cultivation raises. They are also finding a place in plantations where the trees are planted close within the rows making cross cultivations or mowing impossible.

Choice of Herbicide

There is a range of chemicals which can be used for weed control in orchards, most of which have been used at Efford at varying rates. The most satisfactory for routine weed control was achieved by the use of simazine at 2 lb a.i./ac plus paraquat at 1 lb a.i./ac, except where perennial weeds are present. The control of perennial weeds is an increasing problem, as they are present in most orchards and often tend to increase as the result of using some herbicides; docks, thistles and bindweed are particularly troublesome and difficult to control. The only satisfactory control of all of these weeds is by the use of a hormone weedkiller such as MCPA. These can be used safely in an orchard as long as sensible precautions are taken to avoid drift. There is, though, always the risk with this type of weedkiller that careless or accidental spraying could do serious harm to the trees, and a safer alternative is required.

There are other chemicals which have given good results particularly for the control of docks and thistles, though not against bindweed. Chlorthiamid and the closely related compound dichlobenil, have been successful for the control of a range of perennial weeds. The former has unfortunately caused some slight marginal leaf chlorosis on fruit trees and therefore is not recommended, and diclorbenil, in our experience, has given variable results. An alternative is a mixture of aminotriazole and simazine, but the period in which this can be applied is limited as the use of aminotriazole is restricted to after picking and before first flower; also, the weeds must be growing actively for good results. Further work is therefore necessary on this subject, but in the majority of orchards a satisfactory weed control can be achieved by the use of herbicides.

Future Trends

The way in which herbicides are utilized in the soil management techniques in the orchard of the future will probably depend on the conditions on a particular orchard. Where the herbicides are applied overall, they will eliminate competition by the weeds and grass cutting, so achieving the maximum benefit. The best results from this technique are obtained if the trees are planted into an established grass ley which is then killed by the use of herbicides. This provides a much more stable soil condition than if the herbicides are applied to cultivated soil, and reduces the risk of wheel

rutting. A very light mulch over the surface of the soil may also be beneficial in this respect. Where there is a risk of soil erosion, serious wheel rutting or panning, then the best result may be achieved by leaving a grass strip down the centre of the rows and keeping the remaining area weed-free by the use of herbicides. In the early years this strip should be kept to a minimum to reduce competition and encourage the roots of the trees to exploit the maximum area possible. In later years of the orchard it may be desirable to restrict the growth of the tree, in which case the area of the sward could then be increased.

Herbicides thus seem assured of a place in the changing pattern of fruit growing.

CARBON DIOXIDE ENRICHMENT OF EARLY TOMATO CROPS

G. C. Williams, *N.A.A.S. Littlehampton*

The first experiments in this country aimed at assessing the effects of enriching the atmosphere with carbon dioxide during tomato production were undertaken in 1964 at the Lee Valley Experimental Horticulture Station and the Guernsey Experimental Station. The results from both centres clearly indicated a large and worthwhile response to CO_2 enrichment.

In the 1965 season the work was extended, to Efford and Fairfield in addition to Lee Valley.

The main object was to assess the effect of CO_2 enrichment and of night temperature on crop yield, fruit quality and monetary return. Sowings were made in November at Efford and Fairfield and in early December at Lee Valley. The comparison between CO_2 enrichment and no enrichment commenced at the pricking out stage. As it was known that the utilization of CO_2 by plants is affected by the temperature at which they are being grown, two temperature regimes were used and were compared in the experiments. The first of these was based on the temperature regime currently being recommended by the N.A.A.S. for conventional early tomato production, i.e., without CO_2 enrichment, but slightly modified to take account of enrichment by the extension of Stage 3 for three weeks longer than for conventional culture. This was done in order to give a longer period at the higher day temperatures and so permit better utilization of CO_2. This modified regime, which is set out in Table I, was used as a standard and from planting onwards (beginning of stage 3) was compared with another temperature regime similar in all respects except that the minimum night temperature was 56°F instead of 62°F. Except at Lee Valley, where only three treatment combinations were possible, each of the two temperature regimes were grown both with and without the additional CO_2.

TABLE I

Standard temperature regime used in the CO_2 enrichment trials

Plant stage	Night temperature °F	Positive day temperature (maintained by heating system) °F	Ventilating day temperature °F
1. From pricking out to appearance of first truss	58	64	74
2. From truss appearance to first flower	60	64	74
3. From first flower to 7 weeks after picking the first ripe fruit	62*	68	74
4. From conclusion of Stage 3 to the end of cropping	62*	64	70

*In the regime with which the standard was compared this temperature became 56°F.

The only variation of temperature from the regimes laid down was that day ventilation temperature, in the CO_2 compartments only, was temporarily raised to 80°F for a short period during April/May, because CO_2 levels were very much lowered by the ventilation needed to keep temperatures down to 74°F.

The concentrations of CO_2 were periodically checked early in the morning with the vents closed, the aim being 1,000 v.p.m., or a three-fold increase over the CO_2 content of external air. The quantities of CO_2 necessary to achieve this level, approximately 50 lb per acre per hour, were then continuously applied by day, irrespective of the amount of ventilation. The daily injection of CO_2 was timed from half an hour after sunrise until about one and a half hours before sunset. Gas from cylinders was used and distributed in the appropriate compartments by means of perforated $\frac{1}{2}$ in. layflat polythene tubing.

The total period of enrichment following planting varied slightly with each trial and extended to between seven and nine weeks after commencement of picking ripe fruit. When enrichment ceased, the temperatures laid down for Stage 4 were maintained i.e., a positive day temperature of 64°F and a ventilating temperature of 70°F. The night temperature regimes were not amended. Cropping continued on till the normal end of the tomato season.

The following varieties were grown in all trials—Eurocross BB, J 168, Ware Cross and J 154 R.

The Effects of Enriching with CO_2 during the Propagation Period

From sowings made on 20 November at both Fairfield and Efford, enrichment produced yield increases in the order of 2 to 3 tons per acre. The overall increased monetary return as a result of enrichment during propagation was in the order of about £1,000 per acre at Fairfield for a CO_2 cost of £106 (see Table 2). This result is from plants propagated at a minimum temperature of 58°F night/64°F day. The increase in yield and monetary return was greater at Efford, though the cost of CO_2, at £273 per acre, was higher due to earlier 'rooming out' to the growing houses (on 4 January).

Table 2

Effect of enrichment of CO_2 during the propagation period at Fairfield

Crop to 2 August	No CO_2	With CO_2
Yield (tons per acre)	52·3	54·3
Value (£ per acre)	12,370	13,206

The plants which had received enrichment were considerably taller than the controls, had a greatly increased leaf area and were, at planting time, darker green in colour. At Efford, sampling showed that by 4 January, the date on which the plants were 'roomed out' into the growing houses and stood at planting distances, the average dry weight of the enriched plants

was at this early stage over 130 per cent greater than that of the controls. At the same Station, anthesis, the stage at which the first flowers opened, and considered the correct stage for early planting, was reached by the enriched plants on average nine days earlier than the controls (see Table 3).

TABLE 3

Date of opening of first flowers at Efford

Variety	Enriched plants	Unenriched plants	Advantage from enrichment
Eurocross BB	27 January	8 February	12 days
J 168	29 „	5 „	7 „
Ware Cross	29 „	8 „	10 „
J 154 R	3 February	9 „	6 „
Mean	30 January	8 February	9 days

The propagation treatment at Efford showed little difference in the number of branched early trusses between enriched and unenriched plants, but there was a small increase in the average number of fruits on each of the first four trusses of enriched plants (see Table 4). Subsequently there was also evidence of increased fruit size due to enrichment.

TABLE 4

Effect of enrichment of CO_2 during propagation. Average number of fruits per truss at Efford

Truss number	Enriched plants	Unenriched plants
1	9	8
2	9	8
3	9	8
4	11	9
Total	38	33

The sowing date at the Lee Valley was later, i.e., 11 December, and although the same general trends were seen, the increases in plant growth and in early yield were less marked.

These trials suggest that during propagation CO_2 enrichment is worth while, producing as it does larger, heavier plants with considerably increased leaf area. Such plants reach anthesis ahead of unenriched plants and, in some instances, appear to be producing slightly more fruits on the early trusses.

The production of a larger plant, however, could increase the need for support and create problems of propagation space. Early 'rooming out' into the growing houses, to avoid competition for the limited amount of light available in winter is required if the maximum benefits are to be obtained.

Total Effects of Enriching with CO_2

At Fairfield, the mean result of enriching with CO_2 after planting out—at both 56°F and 62°F night temperatures, when compared with the same night temperatures without CO_2—was an increase in gross monetary return of £3,715 per acre. This arose primarily as the result of an increased yield of approximately 14½ tons per acre, and was obtained by 2 August—at the end of 16 weeks picking.

The cost of the CO_2 was approximately £2,100 per acre and, after allowing for the cost of extra packaging the additional weight of fruit, the net advantage was in the order of £1,500 per acre.

The results of growing from a December sowing at the Lee Valley—with and without CO_2 at 62°F night temperature—was an increase in yield from the enriched crop of approximately 12 tons per acre. This, too, was obtained after 16 weeks picking. The gross monetary gain from enrichment was £2,320 per acre.

The results obtained at Efford by the 2 July and after 14 weeks of picking are shown in Table 5. At this stage—which was over six weeks after enrichment had ended—crops grown at 56°F and 62°F night temperatures with CO_2 had produced a 53 per cent mean increase in yield.

Table 5

Total yields (tons) and crop values (£) per acre after 14 weeks picking at Efford

Variety	Treatment							
	Night temperature 56°F				Night temperature 62°F			
	(—CO_2)		(+CO_2)		(—CO_2)		(+CO_2)	
	Yield	Value	Yield	Value	Yield	Value	Yield	Value
Eurocross BB	35·0	7,518	58·0	14,336	37·6	8,249	56·7	14,044
J 168	38·5	8,769	59·1	15,825	39·4	9,208	57·6	15,086
J 154 R	35·2	7,137	55·5	13,458	36·9	8,170	55·9	13,336
Ware Cross	41·2	8,661	63·4	15,131	41·5	9,112	62·2	14,483

It will be seen that all varieties at both night temperatures had at this stage produced approximately 20 tons per acre more fruit as a result of enrichment.

After deducting the cost of the gas, which was £1,603, the increased market value arising from enrichment was about £4,500 per acre.

Night Temperature Effects with CO_2 Enrichment

At Fairfield the yield increases, both at 56°F and 62°F night temperatures, were similar but the monetary return was greater at 62°F—due to a somewhat higher proportion of lower-grade fruit produced at 56°F.

In the Lee Valley trials the yields and returns for both the 56°F and 62°F night temperatures with CO_2 were very similar at the end of 16 weeks picking. There was no 56°F night treatment without CO_2.

At Efford the increases in yield for both night temperature regimes were again somewhat similar, though they were slightly higher at the lower night temperature after 14 weeks picking. Value followed the yield trend and

there was no suggestion of lower fruit quality from the 56°F night temperature regime.

The importance of maintaining an adequate day temperature must be emphasized. This year's work suggests that where CO_2 enrichment is given and coupled with a high day temperature, high night temperatures after planting out are not necessary.

Even though the experimental results obtained during 1965 indicate that a lower night temperature will give equally satisfactory results, it would be difficult in practice, with many commercial heating installations, to run very low night temperatures early in the season and quickly get the temperature lift required to achieve the desired high day temperature used in these trials. It is important that this high day temperature should operate over the full daily period of enrichment. Where such circumstances arise, and where CO_2 is being used, it will be wise to operate night temperatures in the order of 60°F so as to ensure that the necessary temperature level by day can quickly be reached.

Variety Performance

The detailed records from the experiments are still in process of being fully analysed at the time of writing. At this stage there is no indication of any marked difference between the varieties grown in the trials in their reaction to CO_2 enrichment.

At the Lee Valley, the varieties Ware Cross, Eurocross BB and J 168 all performed well, whether or not grown with added CO_2 and also at both night temperatures. The variety J 154 R gave the lowest yield and value in all treatments.

At Fairfield, Eurocross BB and J 168 produced the greatest value for every treatment. Ware Cross cropped as heavily as any variety, but again J 154 R produced the lowest value for all treatments.

At Efford, Ware Cross was consistently the best yielding variety throughout, but J 168, which yielded only slightly less, returned the best value for all treatments. Eurocross BB performed well, especially with CO_2, and again J 154 R returned slightly less yield and a lower total value.

It should, however, be remembered that J 154 R was the only compact habit variety grown, and because of the experimental layout of the treatments was subjected to unfavourable competition for light by the more vigorous varieties.

Part of the trial at Efford was continued through until November, and by this time Eurocross BB and J 154 R in the enrichment compartments were the highest yielding varieties—though all varieties had cropped very heavily.

Disease Assessment

An assessment of the number of *Botrytis* stem lesions present on the plants was made at each Station. Of the main factors examined i.e., CO_2 enrichment, low or high night temperature none was consistently associated with a higher incidence of *Botrytis* at all centres. On an average over all treatments, the highest incidence occurred at Efford and the lowest at Lee Valley. Variety clearly had a bearing on the situation. Eurocross BB was least affected and the worst varieties tended to be Ware Cross and J 154 R.

The incorporation of *Cladosporium* susceptible varieties J 168 and Ware Cross necessitated routine spraying, which could be avoided by the use of *Cladosporium*-resistant varieties, of which Eurocross BB and J 154 R are examples.

Conclusions

The three trials clearly indicate the financial benefits that can be obtained from enriching well-grown, early sown tomato crops. CO_2 enrichment should become standard commercial practice with early sown tomatoes which can be given good management and grown in well-maintained, efficiently heated and clean glasshouses.

The crops reported upon received adequate watering and nutrition, but it was not necessary to modify watering and feeding methods between treatments. Nevertheless, it is important that adequate water and feed be applied if the best results are to be obtained from enrichment and temperature treatments.

The effect of enrichment on later sown crops has as yet not been studied on the Experimental Horticulture Stations, and it should not be inferred from the present results that the same level of benefit will automatically be achieved with later crops.

Short Notes on Other Experimental Work

CONTINUOUS CEREAL GROWING

On six Experimental Husbandry Farms and at the Norfolk Agricultural Station, co-ordinated experimental work is in progress to determine the long term effects and problems likely to be encountered with continuous wheat and barley cropping. Within each trial a new plot area is brought into continuous cereal growing in each of six successive years, thus enabling comparisons of crop yields from cereal runs of different 'age' to be made within any one season. All trials, except the one at the Norfolk Agricultural Station, commenced in 1962–3 and have completed three harvest years. A wide range of nitrogen levels is included in each trial, the highest level well exceeding the present optimum at each farm.

Winter Wheat (Boxworth, High Mowthorpe and Rosemaund)

At all farms there has been a decline in yield with successive cropping. The drop in yield has been greatest at the lower levels of nitrogen application. At Rosemaund a marked reduction in yield of the third crop is attributed to Take-All, while at Boxworth wild oats and grass weeds are becoming an increasing problem. There is some indication at High Mowthorpe that nitrogen requirement has increased in the third successive crop and that heavy applications of nitrogen have delayed the build up of Take-All and Eyespot.

Apart from the co-ordinated trials, field areas on certain husbandry farms have been cropped continuously with winter wheat for several years. At Boxworth, wheat grown for the thirteenth successive year (1964) yielded approximately 35 cwt grain per acre, whilst at Drayton a site cropped with wheat in six years out of the last seven yielded over two tons of grain.

Information on the continuous growing of winter wheat is still very limited and the effects of disease and weeds in relation to soil type are not fully established. However, there are indications that in certain circumstances satisfactory yields from long runs of wheat are obtainable.

Spring Barley (Bridgets, Gleadthorpe and Trawscoed)

In the co-ordinated trials the yield of barley has declined over three years of continuous cropping. The fall in yield has been relatively small at Bridgets and at Gleadthorpe, but at Trawscoed, difficult harvest conditions in 1965 and a high incidence of Take-All in the third year crop has markedly reduced yield. The biggest drop in crop yield again tends to occur at the lower nitrogen levels, but the rate of decline appears to be slower than with winter wheat.

In other trials the yields from the sixth successive barley crop at Bridgets and the tenth to twelfth successive crops at High Mowthorpe have been maintained at levels only slightly below those of rotational barley, by the use of an additional 20 to 30 units nitrogen per acre.

A spring wheat trial at Bridgets and a winter barley trial at the Norfolk

Agricultural Station show the same general trends as the winter wheat trials.

The practice of growing long runs of barley is increasing. Evidence from experiments and farming practice indicate that additional nitrogen is required, together with a high standard of husbandry and an awareness of the risk of disease and the build-up of grass weeds and wild oats.

E. J. Mundy

RECENT ADVANCES IN SILAGE MAKING

A good deal of interest is currently being aroused in two methods of silage making, (a) in sealed towers and (b) in vacuum. As claims are being made for much reduced losses with both methods, investigations are being carried out at certain Experimental Husbandry Farms.

(a) *Tower Silage*

At Bridget's a vitreous enamelled steel tower silo 18 ft 6 in. diameter, 40 ft high, 10,711 cu. ft capacity was filled with lucerne/cocksfoot, Cockle Park type and timothy/meadow fescue leys during the summer of 1964. The herbage was wilted by mowing, crimping and tedding for up to two days before picking up by a full-chop harvester delivering into self-unloading forage boxes. Each load was weighed and sampled before being blown by a tractor-powered blower into the top of the silo. The majority of the herbage was ensiled as a dry matter of between 30 and 50 per cent. Altogether 90 loads were involved: a total fresh weight of 117·7 tons with an average 43·0 per cent d.m. giving 50·6 tons of dry matter.

Each load top-unloaded from the silo in the 1964/65 winter was weighed and sampled. A total fresh weight of 118·2 tons was withdrawn at an average 41·4 per cent d.m. giving 49·0 tons of dry matter. This meant a loss of 3 per cent in the ensilage process in this instance. Some teething troubles were experienced in both the filling and emptying operations at the silo but the actual feeding of 100 cows from a self unloading forage box took only 10 minutes.

A similar determination is being carried out with herbage loaded into the silo during the 1965 summer for feeding out in the 1965/66 winter. Approximately 65 tons dry matter have been loaded in two periods of cutting. In addition, 52 tons of dry matter of wilted herbage (cut from the same fields at the same times as for the tower) were ensiled in two clamp silos for further comparison of relative losses.

At High Mowthorpe an identical tower has been loaded with well over 70 tons dry matter in one period of cutting. The higher capacity may well be due to a better 'chop' being obtained with a different type of forage harvester. Again, a clamp silo has been filled with 200 tons of material at 40 per cent d.m., i.e., 80 tons dry matter, so that comparative in-store losses can be determined.

(b) *Vacuum Silage*

At Drayton in late May 1965, wilted herbage from a perennial ryegrass/white clover mixture was ensiled in a bunker-silo under a Dutch barn and also in a commercial polythene sheet vacuum 'pack' alongside. Loads of double chop forage harvested herbage were weighed, sampled and placed in each silo alternately throughout two days. The bunker silo was filled with frequent rolling, covered with a sheet of polythene and a layer of straw bales on top in the conventional manner and contained 26·9 tons fresh material at 23·2 per cent d.m. (6·2 tons dry matter). The vacuum silage was made according to instructions supplied with the 'kit', evacuated at the end of the second day, then left until required for feeding and contained 24·9 tons fresh material at 23·2 per cent d.m. (5·2 tons dry matter). In addition, on the following day a further 23·4 tons of wilted grass from the same field at an average d.m. of 32·7 per cent (7·7 tons dry matter) was ensiled in a 0·020 inch thick butyl rubber sheet in an adjacent bunker silo and evacuated. Temperatures in all three silages were frequently checked by means of thermocouples, the maximum recorded in the conventional silage was 97°F and in the two vacuum silages 93°F; 341 gallons of effluent was measured from the conventional silage but only 12 gallons from the polythene sheet vacuum silage. Analysis of these effluents showed little difference excepting more sugar and a lower pH of 3·8 in the vacuum silage as against 4·2 pH in the conventional silage. Analysis of cored samples taken in July again showed little difference in the fermentation at that stage, although in the vacuum silage there was rather more lactic acid, less acetic acid and butyric acid than in the conventional silage.

Each load, when taken from the silages for feeding during the 1965/66 winter, will be weighed and sampled for analysis to ascertain respective losses. Digestibility determinations will be carried out and the actual feeding value of the silages assessed as liveweight performance in identical groups of spring born beef animals.

At Liscombe, fresh Autumn grass has been ensiled both under vacuum and in the conventional manner as a comparative study. Some other Experimental Husbandry Farms have also made vacuum silage mainly for practical experience. Regional Nutrition Chemists are, however, closely following up the fermentation process involved in most of these cases. This silage will be fed to both cattle and sheep depending on the circumstances of the particular E.H.F.

R. Bee

BEEF FROM CONCENTRATES OR ROUGHAGE?

A large scale experiment is in progress at six centres in which a study is being made of the productivity and profitability of beef cattle reared on varying proportions of concentrates and silage. Naturally, the circumstances vary between the different centres: at three of them Friesian steers are being

GREAT HOUSE EXPERIMENTAL HUSBANDRY FARM

Fattening store lambs

In-wintering on slats with *ad lib* concentrate feeding (see page 16).

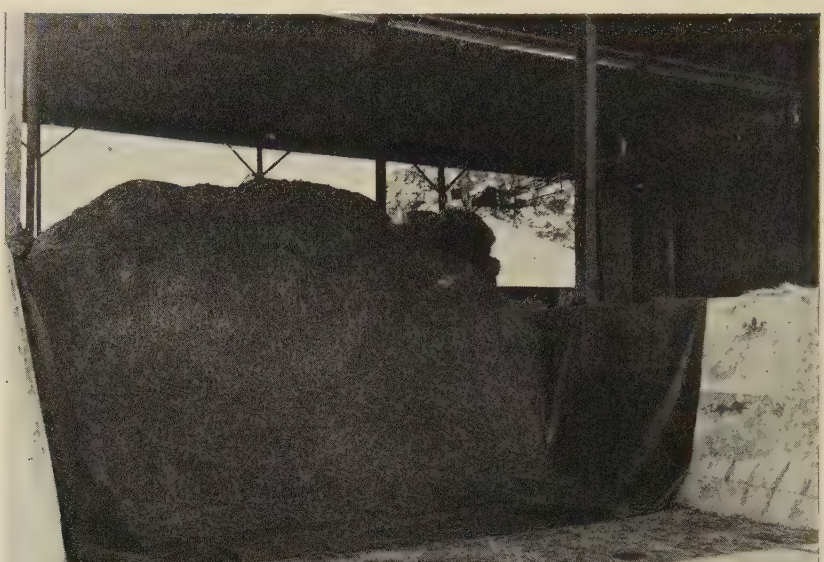
GLEADTHORPE EXPERIMENTAL HUSBANDRY FARM

Vacuum silage

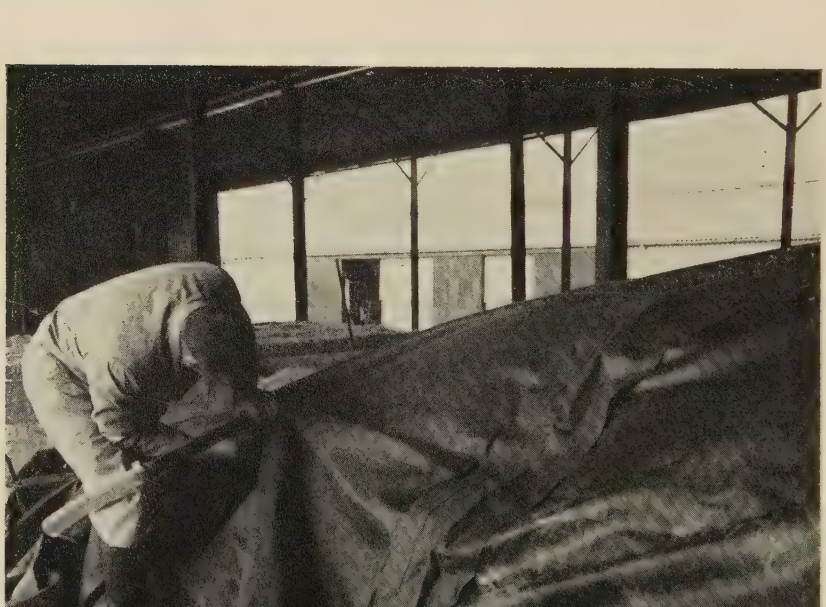
A free-standing clamp enveloped in polythene (see page 35).

PLATE I

Vacuum silage in butyl rubber



Sheeting ready for folding into centre and sealing (see page 35).



Taping the extraction pipe into position.

PLATE II

ARTHUR RICKWOOD EXPERIMENTAL HUSBANDRY FARM

The side of a dyke cut in 1964, showing initial peat formation covered by a layer of silty blue buttery clay (first marine transgression period) overlaid by peat of more recent origin (see page 64).

LEE VALLEY EXPERIMENTAL HORTICULTURE STATION

Mushroom growing in glasshouses

An experiment with mushrooms grown in deep and in shallow trays.

PLATE III

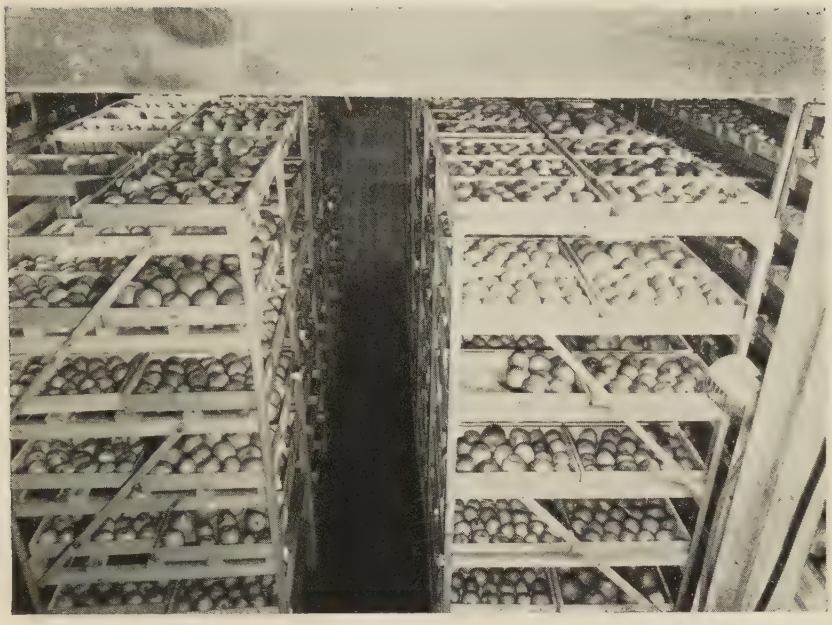
Control of herbage in orchards

Orchard with herbicide applied along the tree rows.

Tractor mounted sprayer for herbicide application round the tree trunk.

Square of herbage controlled by herbicide application.

PLATE IV



Fruits from the National Apple Collection in natural storage at Brogdale

Apple cultivar, Mutsu. Tree 12 years old from planting as a maiden

PLATE V

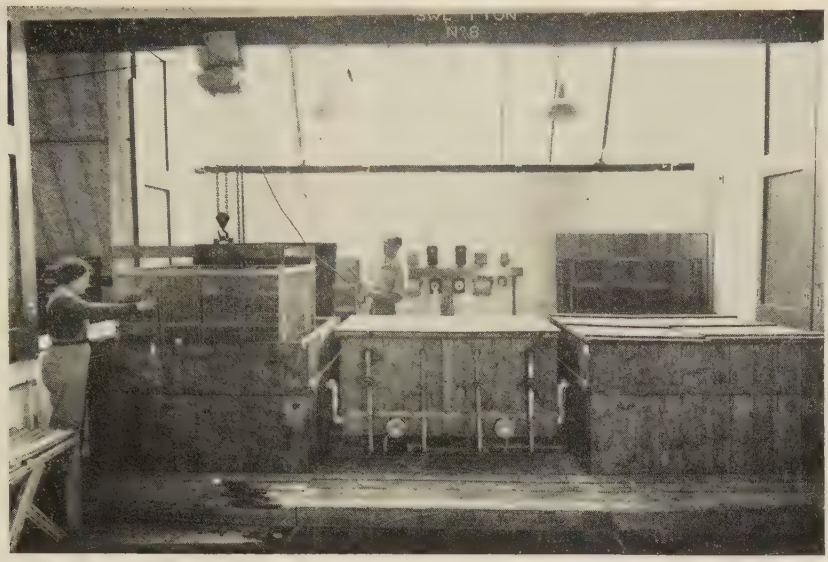
Protecting strawberries with polythene

Polythene tunnels held by wire loops

'Layflat' polythene resting on the plants

PLATE VI

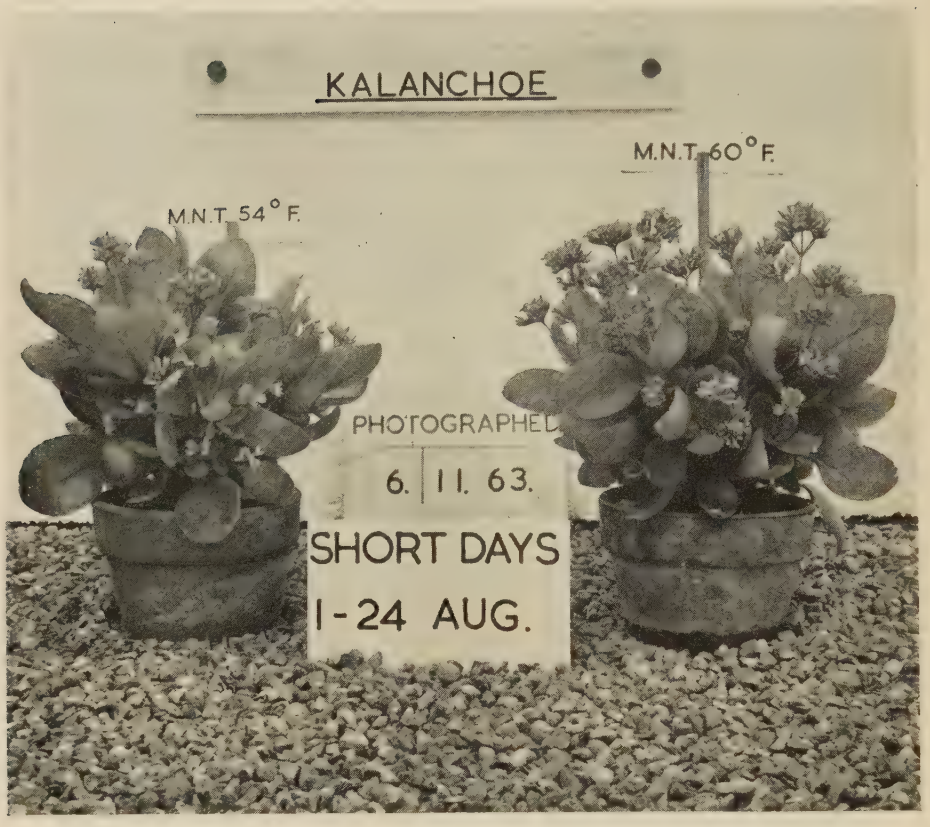
Control of stem and bulb eelworm in narcissus



Narcissus bulbs in wire baskets being lowered into hot water treatment tank, for treatment of bulb eelworm

Symptoms of bulb eelworm in the field. Note stunted growth especially in plants on the right

PLATE VII



The effect of two different minimum night temperatures on the flowering of *Kalenchoe* plants in pots

Left: grown at a minimum night temperature of 54°F

Right: grown at a minimum night temperature of 60°F

Both plants have had short day treatment to induce flowering

PLATE VIII

used, at two, Hereford cross Friesian steers are under study, and at a third using crossbreds, both steers and heifers are involved. The roughage is in most cases grass silage, but at one centre only pea haulm silage is available, and at others hay, either naturally or barn dried, is the fodder under study. In spite of these variations between centres the overall plan of the experiment is the same at all of them, and the concentrate mixture is standard. It is hoped that ultimately the results of this work will not only be of value in planning the actual feeding of beef cattle but will also provide data on the relationship between beef production and the use of land for cereals and/or grass cropping and on the best use of capital resources.

At all the centres this experiment compares the results of feeding varying proportions of concentrates and roughage in both the 3 to 6 month and 12 to 18 month periods. Only autumn born calves are used, reared on a common system to reach about 200 lb at three months old. They are at that point split into treatment groups and at all centres a comparison is being made between a diet where two thirds of the dry matter comes from concentrates and a third from the roughage, and another where the proportions are reversed. At some centres a third treatment, using *ad lib* concentrates with a minimum of hay, is also under trial. At six months all the animals are prepared for a bulky diet by bringing them gradually on to a high proportion of roughage, after which all are turned out for a summer's grazing together. At yarding in the autumn the original treatment groups are in effect split again for types of ration in the ensuing winter. At all centres these range from an all-concentrate diet to a high roughage one, and at the farms using crossbred cattle and hay there is in addition an all-roughage treatment. It is expected that most of the cattle will be sold fat during their yearling winter; those that are not will be turned out again in the spring and sold off grass when fit.

At four centres—Boxworth, Drayton, Liscombe and the Norfolk Agricultural Station—this experiment commenced with animals born in autumn 1964. At the other two—Gleadthorpe and Rosemaund—the work began a year earlier and results are available from the first rear born in autumn 1963.

At Gleadthorpe, six groups each of five Friesian steers were used. Three groups were housed together and fed in the 3 to 6 month period on a low concentrate: high silage ration (up to 4 and 25 lb respectively daily). The other three groups were housed together and fed a high concentrate: low silage ration (up to 6 and 20 lb respectively). The daily liveweight gains obtained on these two rations were respectively 1·2 and 1·7 lb. During the following summer the two groups averaged exactly the same daily gain of 1·6 lb. In the yearling winter, not unexpectedly, the best gains were obtained from high concentrate rations. Overall, the type of diet fed in the previous late winter had no effect on gains in the fattening period; there was however a suggestion that the animals which had had a high roughage diet as weanlings did better on a high silage ration as yearlings than did those which had had less silage as calves, and also that the animals fattened on an all-concentrate diet did best if they had had a high concentrate ration in early life. However, the numbers in each group were very small and information from later rears is necessary before these points can be established with any certainty. A gross margin has been calculated for each treatment group and on the whole there are differences in favour of the high roughage diets. However, they are probably exaggerated by the facts that all the animals

were sold over a relatively short period and at similar weights, so that food costs were the determining factor, and that market prices did not reflect the poorer grading of the roughage fed animals.

At Rosemaund eleven groups each of five Hereford cross Friesian steers were used. Four groups were fed together on a low concentrate: high roughage diet (up to 4 lb concentrates and $6\frac{1}{2}$ lb hay) and four on a high concentrate one (7 lb plus $4\frac{3}{4}$ lb hay). The other three groups were fed all-concentrate mixtures. The liveweight gains over the 3 to 6 month period on the three types of ration were respectively 1·3 and 1·8 (very similar to the Gleadthorpe figures), and 2·1 lb per day. The gains in the following summer did in this case however vary a little according to the type of ration fed in the late winter. The high roughage animals gained 1·8 lb and the low roughage ones 1·7 lb daily, with the one group of all-concentrate calves which were turned out doing only 1·6 lb. Thus there was some indication of compensatory growth taking place while the animals were at grass. In the yearling winter, liveweight gains varied with the level of concentrate feeding but overall there was no effect from the type of ration which had been used in the late calf period. As at Gleadthorpe there were differences in the gross margins per animal and per animal per year between the treatments, on the whole in favour of the high roughage diets. Naturally the conclusions to be drawn on this aspect of the results must vary with the costs attributable to cereals and roughages, and these will vary in relation to each other according to circumstances.

B. M. Scott

BEEF FROM BULLS, STEERS AND RUSSIAN CASTRATES

Four Husbandry Farms (Boxworth, High Mowthorpe, Rosemaund and Trawscoed) have taken part in a national investigation to compare the productivity, behaviour and carcass quality of yard-fed groups of bulls and steers. There was a large measure of agreement between the results of all trials using a particular fattening system. At Boxworth, High Mowthorpe and Trawscoed Friesian cattle were fattened as 'barley-beef' with a limited daily ration of roughage to maintain health. At these three places there was an average improvement of 9·3 per cent in rates of liveweight gain as a result of leaving the animals entire. For all animals of this class in the tests the average improvement was 11·1 per cent. There were savings in the amount of barley-mix required between castration and slaughter amounting to 2·5 cwt per head on the Husbandry Farms and 2·1 cwt per head averaged over all centres.

At Rosemaund, where single suckled Hereford calves were finished semi-intensively the improvement in rate of liveweight gain as a result of leaving the calves entire was 11·4 per cent, which was the same as that obtained from all suckled beef breed calves tested. There were only small savings of food on average in this class as a whole, but at Rosemaund there was a

saving between weaning and slaughter of 1·8 cwt barley-mix and 1·5 cwt of roughage dry matter.

Over all centres there was a limited incidence of 'riding' and aggressiveness on the part of bulls with some dairy breed ancestry. On the E.H.F's this was observed at High Mowthorpe and is no doubt part of the explanation for the fact that the improvement in production characteristics at this farm was very much below average. At Rosemaund, where Herefords were kept, the bulls were particularly docile.

The above comparisons were made between entire animals and steers castrated by the traditional method of cutting and withdrawing the testicles at High Mowthorpe, Trawscoed and Rosemaund and by the rubber ring method at Boxworth. In addition, at Boxworth and Trawscoed some steers were castrated by a method developed by the Russians in World War II for use on Red Army horses. The method consists of removing the sperm-producing internal part of the testicle and leaving the outer hormone-producing region intact. Red Army geldings produced by such a method were found to be larger and more vigorous than normal and the method was then applied to other farm animals with some success.

In the production characteristics measured at Boxworth and Trawscoed it was found that the calves castrated by the Russian method were quite near in their level of performace to that of the entires. Thus whereas entires showed an improvement in growth rate over the normal steers of 13·6 per cent, that shown by Russian castrates was 9·3 per cent, and the food saving of entires was 3·8 cwt barley-mix whilst that of the Russian castrates was 3·5 cwt. The Russian castrates behaved like steers with a complete absence of 'riding' or aggressiveness.

There was very little difference in total carcass weight produced by entires, 'Russian-castrates' and 'normal' steers at Boxworth and Trawscoed. However, in common with results from the national trials the bulls did show a slightly lower proportion of the carcass in the hindquarter (49·4 per cent compared with 50·7 per cent). The 'Russian-castrates' were in this case rather nearer to the 'normal' steers at 50·3 per cent.

For comparative purposes in the national trials, carcasses were classified as 'good', 'satisfactory' or 'poor' for overall conformation and for conformation of loin, ribs and buttock. Generally, intensively fed bulls were no less satisfactory in conformation than 'normal' steers, but at Boxworth and Trawscoed, where 'Russian-castrated' steers were included, carcasses from 'normal' steers were slightly preferred to those from either entires or 'Russian-castrates.' Two out of eight carcasses from 'Russian-castrates' at Trawscoed were rejected for fatstock subsidy payment on account of 'bullish characteristics.' Somewhat surprisingly this had not been noted in any circumstances with carcasses from entires.

Some analytical and eating quality tests were done on joints from carcasses from Boxworth. In parallel with results of tests on carcasses from other sources it was concluded that meat from entires may appear attractive to purchasers because it is lean but was found inferior in tenderness to meat from 'normal' steers. In this respect meat from 'Russian-castrates' appeared to behave very similarly to that from 'normal' steers.

In conclusion, then, it would seem that castration by the Russian method may achieve much of the food savings and higher growth rates of entires, it may avoid the penalty of having a lower proportion of the carcasses in the

hindquarter and may also provide eating qualities not inferior to those of steers. On the other hand the professional cost of the Russian castration operation has to be met and some doubt has been thrown on the market acceptability of Russian castrate carcasses, albeit in a limited test. Hence in a full economic appraisal they may not be so attractive a proposition as the physical results would seem to suggest.

R. Wickens

CALF HOUSING STUDIES

There is a generally held belief that good calf housing will reduce rearing losses and result in an all round improvement in performance. Successful rearing units are, however, operating under very different conditions of housing, and, because few comparative studies have been carried out, there is some doubt about which are the essential conditions of good calf housing. Temperature, ventilation rate and humidity are all thought to be important factors requiring further study.

At Drayton and High Mowthorpe, trials were started in 1964 to compare the performance of calves reared under different regimes of temperature and ventilation control, in order to learn more about the relative importance of these factors.

At Drayton four compartments, each with individual pens for fourteen calves, have been constructed. Two compartments have forced ventilation systems, using 12 in. extractor fans, and two have natural ventilation through hopper type windows and extraction chimneys. Both the compartments with forced ventilation have heating systems, one with electric fan heaters and the other with under floor heating, whilst of the natural ventilation houses one is fitted with fan heaters and the other has no supplementary heating. It is therefore possible to compare the effects of ventilation with and without supplementary heat, the effects of heat and the efficiency of the different heating systems. Each compartment is provided with its own electric meter so that the running costs can be accurately assessed.

At High Mowthorpe a brick built calfhouse has been divided into two, each compartment having accommodation for 24 calves. One end has no supplementary heating and rather inadequate ventilation by modern standards, whilst the other compartment has been adapted to provide automatic control of both ventilation and temperature. Two extractor fans are controlled by a time switch to provide the minimum air changes needed for any given weight of calves in the house, and a third extractor fan is thermostatically controlled to switch in when internal temperatures rise above the preset level. Fan heaters provide supplementary heat.

At both farms other calves are being reared in temporary straw bale shelters erected under a dutch barn at Drayton and in a covered fold yard at High Mowthorpe. This type of accommodation is very much cheaper to provide, as apart from the cost of labour to build the shelters for each batch

of calves, the only capital cost involved is in providing suitable hurdles for the pen fronts. Only part of the cost of the straw bales can be added to this, because they are used for bedding afterwards. Up to date no startling differences in the health or performance of the calves due to the different types of housing have emerged. Obviously the response to providing artificial heat will vary according to prevailing weather conditions. At both farms the aim in houses with automatic control is to achieve an even temperature of 55°F to 60°F in the early stages and drop this gradually during the rearing period to a minimum of 45°F, whilst using the forced ventilation systems to prevent any undue build up in humidity and prevent condensation. The heating and ventilation systems appear to be capable of achieving these objectives and at Drayton there is some indication that the provision of forced ventilation has resulted in improved liveweight gains, particularly in the later stages of the rearing period. At High Mowthorpe, differences have been small but there was clearly an improved performance due to temperature and ventilation control in a batch of Friesian calves purchased in December 1964. As the temperatures were low at this time there were greater differences in the conditions in the three types of house than with early autumn or spring intakes of calves. At both places the calves reared in the temporary pens under a barn roof or in a covered yard have done well, unless they encountered a prolonged spell of severe cold. It would appear that this method of housing is perfectly satisfactory for calves bought in during early autumn or in spring, but in the North East of England mid winter temperatures are frequently too cold to recommend it as a method of housing calves purchased in the November to March period.

Costs

At High Mowthorpe, the capital cost of providing the increased insulation, improving the ventilation and installing all the electrical apparatus amounted to approximately £12 per calf more than in the less refined house. Maintenance and repair costs on the fans have been fairly high, but it would appear that this type of installation could be justified for the specialist rearer who would be putting a large number of calves through the house in each year, and thus spreading his overhead costs.

Running costs are being accurately calculated at Drayton, where the cost of electric power for operating the extractor fans was approximately one penny per calf per week. The costs of heating were much more expensive and varied widely, depending on weather conditions during the rearing period and the type of heating used, ranging from 4*s*. 6*d*. per calf to 12*s*. 0*d*. per calf for the rearing period.

Underfloor heating has not been a great success. The advantage of being able to use cheap electricity at the 'off peak' tariff has been nullified by the higher consumption of power, when compared to fan heating. Added to this is a disadvantage in that bedding is difficult, because it cannot be allowed to build up to any depth and thus insulate the calf from the floor. Although cheap, shavings or sawdust had to be removed and replenished at least three times a week.

Conclusions

It would be foolish to make any final assessment of results when the trials are still proceeding, as it is hoped to obtain more experience of performance over a wider range of climatic conditions. The early indications are that the provision of good draught-free ventilation by extractor fans is proving to be beneficial and economic at both farms. Providing supplementary heat is relatively more expensive and the economic benefits are not so obvious. In a well constructed calf house under the relatively mild weather conditions experienced in early autumn or spring it is doubtful whether any supplementary heat is required; good ventilation appearing to be more beneficial and cheaper to provide.

R. B. Mair

BREEDING FROM LAMBS AND SHEARLINGS

The present trend in sheep production as in other branches of farming is towards intensification. There are several ways in which this may be achieved. More sheep may be kept per acre, more lambs produced per ewe, or perhaps a combination of both. Lamb production per ewe can be increased by a variety of methods. Two lamb crops per year or more lambs at each crop, increase the total number of lambs produced per year. Productivity over breeding life may also be increased by taking an extra lamb crop per ewe at twelve months of age. In the past many flockmasters have been deterred from this course by the fear of harmful effects on the subsequent breeding performance of the ewe.

In order to compare the prolificacy, milking capacity and useful breeding life of ewes which were first bred from as lambs, with ewes first bred from as shearlings, an experiment was carried out for a number of years at four Experimental Husbandry Farms.

The breeds and crosses used in the investigation were as follows:

	Boxworth	Bridget's	High Mowthorpe	Trawscoed
Breed of ram used on ewe lambs	Wiltshire Horn	Clun	Suffolk	Welsh
Breed of ram used on shearlings and subsequently	Oxford	Clun	Suffolk	Border* Leicester
Breed of ewe	Scotch Half-bred × Suffolk	Clun	Scotch Half-bred	Welsh

*After the first two lambings

At each of these centres about 100 ewes were bred from as lambs and the same number bred from as shearlings. The rearing of these ewes was necessarily spread over several seasons.

At all the farms except High Mowthorpe one of each pair of ewe lamb twins was allocated to each group. Single lambs were paired by live weight and one of each pair allocated to each group. In this way an attempt was made to equalize the groups as far as possible for live weight. At High Mowthorpe no pairing was done and twin and single lambs were allocated to the groups completely at random.

In each year the group that was to be bred from for the first time as lambs was put to the ram a month later than the rest of the farm flock. The ewes to be bred from for the first time as shearlings spent their first winter on the farm as stores. Where possible they were run with the lamb group after the ram had been removed. For the lambing at two years old, rams were turned out at the normal tupping time for the farm. In subsequent years the two groups were bred as one flock with the rams turned out at the normal time. The ewes were kept in the flock for their useful breeding life. This was as long as eight years at some of the farms but at Trawscoed all ewes were culled at five years old.

The management and feeding of the ewes and lambs, including the age at which the latter were weaned, was as normally practised on each farm. Each year special care was taken to ensure that the management of the two groups and their progeny was the same.

At all the farms, ewes lambing at one year old gave a smaller lamb crop than older ewes. The lambing percentage varied from 78 per cent at High Mowthorpe to 51 per cent at Bridget's. In the following year it was usual for ewes bred from once to produce up to 26 per cent more lambs than ewes lambing for the first time at two years of age. In subsequent years at all centres, ewes bred from for the first time as lambs have done as well or better than their contemporaries bred from for the first time as shearlings.

It is not clear whether size or maturity govern fertility in ewes served in their first year. At Boxworth it was found that ewes which failed to produce a lamb in their first year were on average only 3 lb lighter at tupping than the ones which did conceive. At High Mowthorpe it was also generally the lighter lambs which failed to conceive. Birth weights of lambs born to the two groups of ewes were similar at each farm. Both groups reared their lambs well and there were no differences between them, apart from the extra lambs born to the ewes which lambed at one year old.

Fleece weights were recorded throughout the breeding life of the ewe. It was found that there was little difference in the total amount of wool produced by ewes of either group.

Breeding from ewe lambs means that more care must be exercised in management and extra feeding. This implies that the cost of rearing a lamb is higher than in the case of shearling ewes. This is more than accounted for by the extra lamb crop produced by the ewes bred from at one year old.

The results of this experiment indicate that lambing at a year old did not adversely affect the breeding performance of these ewes in subsequent years. There is no evidence to suggest that ewes lambed at one year old wear out earlier than those bred from for the first time as shearlings.

J. C. Wilcox

FEEDING OF HILL EWES

One of the most important and controversial issues affecting the productivity of the hill ewe is the type and level of food provided for her during the winter. In Wales, the peak lambing period falls in late March and early April, which means that the critical stage of late pregnancy (February and early March) as well as the first month after lambing coincides with the time when production from the hill pastures is at its lowest. Inadequacy of the diet of the hill ewe during this critical period can obviously affect the all-important lambing percentage and the final economic results of the hill farm. Furthermore, it is of equal importance to maintain the ewe in milk after lambing so as to ensure a strong lamb. This means that lambing must be late enough to coincide with a reasonable supply of grass. There may well be a tendency to lamb too early in some hill areas in Wales.

In recent years, supplementary feeding of hill sheep during the late pregnancy period has been increasingly advocated. Experiments were carried out at Pwllpeiran E.H.F. prior to 1963 on supplementary feeding of two and three year old in-lamb ewes. This work showed that the feeding of high protein concentrates (22 to 24 per cent crude protein) to mountain ewes was not satisfactory and that other methods such as folding on swedes or controlled grazing on specially prepared grass foggage were more successful. The results indicated that the ewes given high protein supplement for six to eight weeks before lambing weighed less at shearing time (mid July), produced less wool and their lambs weighed even less than the control group which had received no supplementary feeding-only grazing on improved lower hill.

As a result of these preliminary trials, an experiment with two year old mountain ewes was initiated to compare various levels of protein in the supplementary feed. In 1964, and 1965, four levels of protein, namely 10, 12, 15 and 18 per cent were compared with a control group receiving no supplement. All the ewes grazed the same area of land and were fed hay as and when necessary (e.g., in periods of inclement weather). The difficulties of feeding the various supplements to different groups of ewes were overcome by using a set of portable pens and a five-way drafting race to separate the groups for feeding every other day.

The results, over two years, indicate that the optimum protein level is in the range of 12 to 15 per cent crude protein. The performance (i.e., lamb birth weight, lambing percentage and rearing percentage) of the ewes given the 12 per cent protein supplement was superior to that of ewes given lower and higher protein levels, while lamb weaning weights of the 12, 15 and 18 per cent were similar, being 1·8 lbs heavier than the control group. An interesting feature in the results is the relatively low lambing percentage and rearing percentage of the 18 per cent protein group. The consistent results obtained during the two years indicate that (under the Welsh system whereby in-lamb ewes receive supplement on the enclosed hill or 'ffridd') there are no advantages to be gained by feeding a high protein supplement.

Over the past decade, the ever increasing labour scarcity in hill farming areas has resulted in the number of ewes per man being nearly doubled, and in the future one can visualize one shepherd looking after 1,500 ewes. Bearing this in mind, new techniques of management will have to be studied in order to enable the reduced labour force to maintain and, if possible,

increase production. Under free range mountain conditions where stock behaviour, degree of shelter, aspect, altitude etc., are so important, coupled with an extremely variable botanical composition, it is almost impossible to conduct even a fair comparative trial.

However, during 1964 and 1965, we have carefully recorded the performance of in-lamb ewes of the same age groups on supplementary feeds, comparing a self-help system with the more traditional hay and concentrates. The food used in the self-help system is manufactured as a large block weighing 56 lbs, and the essential ingredients are 50 per cent cereals, 6 per cent urea, 15 per cent common salt, 2 to 3 per cent minerals, 26 per cent molasses and a resinous binding material which also makes the block reasonably weatherproof. These blocks are distributed over the mountain at suitable points at the rate of one block for every 25 to 30 ewes and are renewed every six or seven days, thus saving daily routine work. Approximately 400 ewes were wintered on 700 acres of enclosed but exposed mountain land running in altitude from 1,600 to 1,850 ft above sea level. The main herbage species are heather, nardus, molinia, sedge and cotton grass.

The ewes were allowed access to the blocks for 11 weeks and the average consumption was 5 oz per day (i.e., a cost of 12*s.* per ewe).

From previous experience of wintering in-lamb ewes on this mountain area, one could not expect a lambing percentage of more than 80 per cent in a favourable winter and spring, while over a period of years the average would be below 70 per cent. In 1964 and 1965, when given this supplement, the lambing percentage averaged 93 per cent and lamb birth and weaning weights were above average (6·5 and 38·9 lb respectively). The hay and concentrates system gave a lambing percentage of 91 per cent, a lamb birth weight of 6·2 lb and a weaning weight of 37·4 lb. These ewes were grazing at a lower altitude on agrostis/fescue pastures at a stocking rate of $3\frac{1}{2}$ ewes per acre and although the food cost was lower (i.e., a cost of 10*s.* 6*d.* per ewe), over the 11 week period labour requirements were higher. There is also some evidence that lamb losses are higher on the hay and concentrates system.

It is a known fact that a hill ewe has to travel miles every day to satisfy her dietary requirement and many hill farmers hold the view that supplementary feeding is wrong because it deters and lowers the ability or inclination of the hill ewe to forage for herself. However, experimental evidence shows that significant and profitable increases in production can be obtained by supplementary feeding and the large fluctuations in numbers of sheep lost and lambing percentages experienced without feeding are very much reduced. There is no doubt, however, that the development of a feeding system that would not have an adverse effect on the will to survive and the foraging or ranging habits of mountain sheep would make an important contribution to production and profitability of these farms. The indications are that we are more likely to attain this by some form of self help system which does not interfere too much with their natural behaviour.

M. Roberts

THE VALUE OF POULTRY MANURE ON GRASSLAND

Due to the lack of information about the value of poultry manure as a source of nutrients for grassland, a series of experiments were set up at Great House E.H.F. in 1960 to compare the responses from poultry manure with those from inorganic nitrogen.

Three types of poultry manure were used. These were long term deep litter, short term deep litter (which it was thought would resemble broiler litter), and fresh un-leached battery manure which contained no shavings. The litters were applied at the rates of 2, 4 and 8 tons per acre and the battery manure at $2\frac{1}{2}$ and 5 tons per acre. An attempt was made to rule out the effects of phosphate and potash contained in the poultry manure in order to confine the evaluations to terms of nitrogen efficiency. This was done by either adding amounts of inorganic phosphate and potash equivalent to those contained in the deep litter, or by applying adequate basal dressings of a 0:14:28 fertilizer to all plots in the battery manure experiment.

Chemical analysis indicated that long-term deep litter, which was well-rotted down, contained 32 units N per ton. The results were similar to those from equivalent amounts of inorganic nitrogen, when both were applied in the summer, and the plots were cut in the autumn. In terms of the responses the litter produced, it was equivalent to 36 units of inorganic nitrogen per ton at both the low and medium rates of application. Neither type of fertilizer produced any carry-over effect in the following spring.

The short term deep litter contained many un-rotted shavings and analysed at 26 units N per ton. When this type of litter was applied in the spring, the nitrogen it contained was 50 per cent as efficient as inorganic nitrogen on the basis of yields obtained at the first cut, but was only 25 per cent as efficient based on yields over the year. The fall in efficiency at later cuts, leading to the lower overall efficiency, was thought to be due to the fact that nutrients became involved in the breakdown process of the shavings and were consequently unavailable to the grass. This type of litter, applied in the spring, was only equivalent to 6 to 8 units of inorganic nitrogen per ton.

The battery manures were applied either in the spring or autumn and analysed at 30 units N and 21 units N per ton. It was relatively more valuable when applied in spring when the nitrogen it contained was over 70 per cent as efficient as inorganic nitrogen applied at the same time, and was equivalent to just over 20 units inorganic N per ton. Comparing autumn dressings of battery manure, again with spring dressings of inorganic nitrogen, the efficiency fell to about 50 per cent and the equivalent value was about 10 units inorganic N per ton. There was a better carry-over effect in the following spring from autumn applications of inorganic nitrogen than from autumn dressings of battery manure.

Although the three main types of poultry manure produced on farms were tested, there remain several aspects still to be investigated. In particular, these are the effects of application in the winter or summer, although this may be pre-determined by practical considerations, and the effects of storage, especially of the battery manure, if it is impossible to apply this fresh.

B. Bastiman

TRIALS OF CHINA ASTER VARIETIES FOR CUT FLOWER PRODUCTION

In the last few years several new or improved strains of China aster have been introduced, particularly from Germany and other European countries. Some of these, such as the late flowering Duchess strains rival early chrysanthemums in bloom, size and quality.

At the Lee Valley Experimental Horticulture Station trials have been undertaken to compare new early flowering varieties with the traditional early variety, Queen of the Market, which although prolific is not of top quality, to look for new introductions which might lengthen the season, and to show growers the best of the mid-season and late flowering varieties in order to assist them in the choice of suitable varieties for particular requirements.

The early varieties Extra Early Burpeeana and American Beauty have given blooms of rather higher quality than Queen of the Market, the standard variety for early production. American Beauty flowers at the same time as Queen of the Market but Extra Early Burpeeana is a little earlier. Although these two newer varieties have better quality flowers, there is still a need for improvement of the varieties which flower during this early period.

In the mid-season range Pompon in colour shades has replaced the dwarf Lilliput both for bloom quality and length of stem. Bouquet (Powderpuffs) is still a most reliable cut flower variety, and for growers preferring single blooms Madeleine in colour shades is very prolific.

The later flowering varieties tend to be of higher quality, and in this section the Giant Princess and the newer Duchess strains are outstanding for size of bloom.

F. G. Lloyd

APPLE STORAGE IN POLYTHENE-LINED BINS

Under conditions of refrigerated, controlled atmosphere storage, some varieties of apples tend to lose weight due to moisture loss. For instance, 100 tons of Worcester Pearmain would have averaged a moisture loss of 3·7 tons in 1962 and 1963 after 10 to 11 weeks storage in bulk bins. The temperature was around 34°F, a concentration of 6 to 8 per cent CO_2 was maintained and the bins had ventilation gaps equivalent to 4 per cent bottom area. It is obviously worthwhile trying to reduce this loss.

For three years, storage trials have been carried out with Worcester Pearmain at Luddington Experimental Horticulture Station. The store holds 11 tons and cooling can be achieved faster than in a normal commercial store. Moisture loss from fruit stored in orchard boxes was roughly the same as from 4 per cent ventilated bulk bins. Enclosing a stack of boxes in polythene reduced moisture loss.

The thickness of polythene is not important; 150 gauge is easier to use than 500 gauge. Simple lining of the bins is sufficient, the sheets being

loosely overlapped to cover the bottom and sides and the fruit at the top. If one-third of the top is left open it is not as efficient as complete enclosure. Storage temperature must be watched carefully as the fruit in bins lined and covered with polythene takes longer to cool and remained some 2°F higher than that in orchard boxes. In two years out of three when the store was opened, the number of fruit affected by rot was slightly higher where polythene was used but this was more than offset by the greater weight of fruit. By reducing moisture loss, the apples were also brighter, firmer and looked a more attractive sample.

Worcester Pearmain responds well to this treatment when stored at Luddington but there was doubt about the response of varieties subject to storage scald. In collaboration with Ditton Laboratory, new trials, using Bramleys Seedling were started in 1964. The CO_2 concentration was maintained between 8·0 per cent and 10·0 per cent and the fruit temperature mean from 18 October, 1964 to 6 April, 1965 was 39·2°F when stored in bushel boxes. Again, the temperature of fruit covered with polythene in line bins was higher. The number of apples with rot was increased but fruit moisture loss was decreased.

When storage scald was assessed, it was found that by 6 May, 1965, five out of every hundred apples in bushel boxes were affected. A similar amount occurred in bulk bins with ventilation equivalent to 8 per cent of the bottom area. In bins with half this ventilation, scald was doubled and with no bottom ventilation, scald was fivefold. In bins where the fruit was completely enclosed in polythene the results were disastrous. Nine out of ten apples were affected by storage scald.

The work is continuing but the results will not always be so clear cut as storage scald is not serious in all seasons. In 1964, storage conditions which reduced moisture loss by decreasing the amount of ventilation, seemed to be responsible for the increase of scald in Bramleys Seedling. Bins with 4 per cent ventilation are common in commerce. The results of one year's trial suggest 8 per cent ventilation would be preferable.

A. R. Carter
J. Ingram

STRAWBERRY HERBICIDE EXPERIMENTS AT EFFORD

Since 1963, experiments have been carried out on a fine sandy silty loam of impeded drainage, on strawberries generally planted August or September for cropping as one-year plants. Early experiments showed that simazine (1 lb a.i./ac) did damage and caused crop reduction when applied after planting, the earlier the planting and the less time between planting and simazine application, the greater the damage. Thus on *this soil* simazine at 1 lb a.i./ac cannot be recommended within four weeks of planting, but after this time, and the necessary hoeing to clean the established plants, this application will only depress the crop of several varieties by about 10 per cent and will keep the plants weedfree until strawing the next year.

The next series of experiments compared chloroxuron 5 lb a.i./ac immediately after planting followed by simazine 0·5 lb a.i./ac in early December. This treatment was most successful and compared with hand hoed controls there was no crop reduction. However, chloroxuron would not adequately control grass and mayweed seedlings and where these are a problem, this otherwise simple, inexpensive herbicide programme for newly planted strawberries is not satisfactory.

Experiments to be cropped in 1966, therefore, have been sprayed after planting with simazine at 0·5 lb a.i./ac repeated at varying times. Other plants planted in November and in the spring have also been sprayed with this low rate of simazine and growth does not appear to be checked. Simazine at 0·5 lb a.i./ac will control grass and most other weed seedlings.

Cold stored runners sprayed immediately after planting in July, with 6 oz a.i./ac simazine showed no damage, and this gave a better weed control than chloroxuron (5 lb a.i./ac). It appears that cold stored runners behave very similarly to fresh dug runners.

Unfortunately, none of these herbicide programmes will control spring germinating knotgrass (*Polygonum arviculare*) and observation studies showed that in spring, only very high rates of simazine that killed strawberries would control this weed. Thus where this weed is a problem, a herbicide programme can be used to eliminate the need for autumn and early spring hoeing, but once knotgrass germinates late spring cultivations—as shallow as possible—are essential.

The rates of autumn chloroxuron, and simazine, or hand hoeing followed by simazine, mentioned above are also suitable for strawberries to be cloched in the spring.

On other soils these rates of simazine may be damaging. In general, on sandy loam soils, similar to those at Efford, these rates of simazine may be used but on coarser sandy soils less simazine may be absorbed into the soil and plant, damage can result. On these soils growers should test small plots to find the safe limits of material. On highly organic, or peaty, soils the opposite is true and higher rates may be necessary to kill the weed seedlings, because much of the simazine is absorbed by the organic part of the soil.

Charcoal root dips have given good protection against simazine damage at several centres including Efford. Experiments are in progress to see if the expense of the charcoal dip is warranted and whether it will allow the higher rates of simazine, which give better weed control, to be used.

Hilary M. Hughes

BRUSSELS SPROUTS FOR MECHANICAL HARVESTING

The advent of machinery for sprout harvesting will lead to an entirely new approach to the method of growing, and a new look in the plants themselves. The new look must be one of uniformity and good quality with long straight stems, well-spaced sprouts and brittle leaves, while the method of growing

must incorporate closer spacing and the clearance of a whole area at one pick, instead of picking over one field several times.

Machines are not yet commercially available, but two are now in a well advanced experimental stage. As it is now envisaged, both will be needed for the full mechanization of sprout harvesting. A general vegetable harvesting machine designed by the National Institute Agricultural Engineering will cut sprout plants at ground level, conveying them by elevator to a pallet box, or trailer, so that they can be taken to the headland or packing shed. This machine is likely to be an expensive one but could probably be hired out by contractors and it is expected to be able to lift about four acres a day. The second machine, which the manufacturers hope to market in 1966, is a sprout stripper, removing sprouts from the cut stems by pulling them through a hole not large enough to let the sprouts through as well. The machine works from a half horse power motor and should be able to harvest 400 to 600 pounds of sprouts per hour.

Before either machines can be used on the plants, it is necessary to remove the leaves. The leaves of some sprout varieties are more brittle than others and this feature can be bred into varieties and is being used at the National Vegetable Research Station.

For cut-down harvesting it is necessary to have a good length of stem containing mature sprouts, rather than the gradual maturity up the stem needed for field picking. Many varieties will produce this solid cylinder of sprouts if they are stopped when the first sprouts are about $\frac{1}{2}$ to $\frac{3}{4}$ in. in diameter. A good stem should produce about one and a half pounds of sprouts and a uniform stand of such plants would ensure that time was not wasted by poor stems passing through the machinery. The machines will not be able to distinguish between good and bad sprouts so the varieties used should not produce loose sprouts at the base of the stem. Closer spacing in the field will give a more efficient use of a machine travelling over the area.

The stripping machines, in their present form, work best with fairly long thin, straight stems and sprouts not too closely packed. Some of the earliest varieties are rather short and thick with very close packed sprouts so these may not be as suitable for machine harvesting.

To use the machinery to best advantage a grower would need to grow a succession of sprouts so that one area could be cleared every few days. This will be made possible by use of early, mid-season and late varieties, sowing spacing and stopping dates and the ability of plants to hold the yield over a short period without the deterioration of the crop.

So far, much of the work done at the Experimental and Research Stations has provided the information required to produce early and mid-season sprouts for cutting down complete plants at one harvest. Good quality sprouts have been produced by this method from mid-August to mid-December and varieties such as Early Half Tall, Avoncross, Champion Packer, Westlandia Special and Seven Hills show great promise and when grown at 2 ft spacing they have all given over five ton per acre yields. Trials have shown that closer spacing delays maturity, but increases are obtained in total yield down to 18 in. spacing. If plants are stopped too early in their growth, that is before sprouts are forming or the plant has reached its full height, the resulting sprouts are loose and of poor quality. Too late stopping, when the lower sprouts are almost mature has no effect at all compared with

unstopped plants which then mature more gradually up the stem and are late in maturity. Between the two extremes the stopping time can be used to influence maturity within about three to five weeks from any one sowing date.

Although some of the new techniques have been worked out through experimental work there is still much to be done before sprout growing for mechanized harvesting can be considered a foolproof proposition. The major problem at the moment is sprouts for the late season. Late varieties must be found which will hold the sprouts in a good condition until well into the New Year and here, in addition to the hazard of normal botrytis rotting, internal browning presents another stumbling block. This again is partly a varietal feature and may be overcome by the plant breeders. Direct drilling is another line of investigation which needs to be more thoroughly investigated and the degree of brittleness of leaves is a character which has not been recorded in variety trials up to the present time.

Thus while much has been achieved and it will be possible to give growers quite helpful advice about the new technique of growing for mechanization, there are still plenty of problems left to the research workers in this field of production.

Jean M. Garthwaite

SOME NEWER VARIETIES OF EARLY POTATOES

New varieties and un-named seedlings of potatoes are continuously being tried at Rosewarne Experimental Horticulture Station in the search for better ones for early lifting. In addition to many of the older varieties, relatively new ones like Arran Pilot, Home Guard, Ulster Chieftain, Ulster Premier, Ulster Prince, Craigs Alliance, Craigs Royal, Red Craigs Royal, Sutton's Foremost and Chancellor, and also many seedlings have been tried in the past. Notes on other new varieties which have been grown more recently in collaboration with the National Institute of Agricultural Botany are given below. It should be borne in mind that the remarks apply to crops grown in well drained but deep loams in a fairly high rainfall area from plantings most often made in late February or early March. Lifting may start from mid-May to early June according to season. The behaviour of these varieties under drier or less windy conditions or from later plantings may be somewhat different.

Arran Comet:

Oval tubers rather like Home Guard. Earlier than Arran Pilot and most other varieties and generally continues to give heavier crops throughout the season. More susceptible than Arran Pilot to blight when it occurs early in the season and may also be more quickly affected by scab in some conditions. Dry rot can at times be troublesome in the seed trays. Growth is sturdy but not over-vigorous and is less affected by drought than is Home Guard. Sprouting slightly slower than Arran Pilot.

Sirtema:

A variety of Dutch origin. Tubers thick oval to round oval, a little irregular in shape. Eyes shallow to medium; light yellow flesh. Not quite as early as Arran Comet but generally earlier than Arran Pilot and producing a bolder sample early in the season. Should be dug early as tubers may in some conditions crack if left in too long. Sprouting at about same rate as Arran Pilot. Haulm slightly less vigorous than Arran Pilot and very susceptible to blight in the foliage. Only slightly more susceptible to blight in the tubers than Arran Pilot.

Ulster Magnet:

Tubers fairly long thick oval to roundish oval. Rather variable in performance, cropping at about the same rate or less than Arran Pilot. Tubers tend to be large later in the season. Growth fairly compact, less vigorous than Arran Pilot.

Pentland Envoy:

Tubers oval, fairly uniform. Fairly early but not outstanding and slower to crop than Arran Pilot. Among the newer varieties is one of the first to become infected with scab at Rosewarne. Losses of seed from gangrene were reported in one season. Rather slow to sprout, haulm low growing.

Ulster Sceptre:

Longish oval to kidney-shaped tubers. An early bulker with a few large tubers per plant; may be very large late in the season. Earlier than Arran Pilot. Moderate semi-erect to erect haulm. Shows some resistence to blight in the foliage.

Maris Peer:

Tubers short oval, regular, of good appearance. Crops well but not quite early or bold enough for early lifting. Produces a very even sample as a second early. Haulm even, moderately tall.

Pentland Glory:

Kidney to long thick oval tubers, sometimes a little curved. Grown for one year only; in 1965 bulked at about the same rate as Arran Pilot. Haulm low to medium.

Ulster Classic:

Tubers oval with bright red colour near eyes, more even in shape than Arran Pilot. In 1965 it bulked early, was earlier than Arran Pilot and continued to bulk well through the season. Haulm moderate. One of the last varieties to become infected with blight.

J.14. (Clarke):

Tubers flattish to thick oval, fairly uniform. Said to yield later than Arran Pilot but in 1965 was earlier at Rosewarne. Haulm semi-erect, moderate.

Aronia:

A variety of German origin. Thick oval even-shaped tubers marked with red near the shallow eyes. Not quite as early as Arran Comet but almost as early as Ulster Premier. At earlier liftings ware tubers a little small but fairly even and attractive samples produced. Very susceptible to blight in seed crop or if left in as a second early.

E. G. Ing

COMBATING STEM EELWORM

Stem eelworm has been recognized as an important pest of narcissus for over 50 years and the method of controlling it was evolved nearly as long ago, but it is still the most serious pest of narcissi.

The original recommendation for control was to treat the bulbs for three hours in water at 110°F—this was known as hot water treatment (H.W.T.) —and with a few modifications introduced over the years, this is still practised. The original treatment was, and still is usually satisfactory, but in some instances the control of eelworms was not complete. In the 1920 to 1930 period, especially in the South West of England, the recognition of eelworm was often confused by heavy attacks of other pests, particularly the large bulb fly, and bulb losses due to eelworm were sometimes blamed on the latter.

Over the years various materials have been added to the water in the tank to improve pest and disease control. The present practice is to use both a fungicide and a wetter. The fungicide prevents spread of disease during treatment. Formaldehyde is preferred because it is non-poisonous and it has the extra advantage of killing eelworms in the water of the treatment tank. The wetter, by improving the wetting of all bulb surfaces, helps to eliminate air bubbles which might otherwise insulate eelworms from the effects of heat.

In the 1950's the acreage of bulbs increased rapidly and although H.W.T. was still practiced as before, the eelworm problem increased. This was partly due to rapid and indiscriminate build up of stocks, but also partly due to the elimination of other bulb pests when more effective insecticides became available which left the eelworm and its effects in the limelight.

At this time the standard H.W.T. of 110°F for three hours was still being used, and it was suggested that bulb eelworm had developed resistance to H.W.T. at 110°F. It was shown by Woodville, however, that the races of eelworms submitted to H.W.T. were now no more tolerant to heat than previously. He and others have also proved that while the more active stages of the eelworm can be controlled by three hours treatment at 110·5°F, the more resistant stages which are present later in the growing season, especially after a period of dry storage, require higher temperatures for the same duration of treatment.

Treatment at 112°F for three hours has been widely adopted and this is now proving to be satisfactory.

It is fortunate that narcissus bulbs proved to be more tolerant to the effect of heat than had been supposed and we have even seen bulbs treated at 115°F *at the proper time of year* growing heathily and vigorously. At 112°F, the after-effects of treatment at the right time are not serious although there may be some flower damage.

In recent years some growers have pre-soaked their bulbs for two to three hours before H.W.T. which seems to activate the more resistant eelworms making them more susceptible to H.W.T. Pre-soaking of infested or doubtfully clean stock can be justified but it lowers the resistance of bulbs to H.W.T. damage, especially where wetters are used in both the pre-soak and during H.W.T. Some wetters are more damaging than others and the non-ionic type is preferred.

The most serious and long term damage to the crop follows root damage which is caused when bulbs are treated late in the season. Very early treatment and H.W.T. at higher temperatures can damage the next years flowers but without affecting the vigour of the stock. Flower damage has to be avoided when growers want a sound flower crop in the first year and it is least likely to occur if the H.W.T. is done after the flowers have formed within the bulbs. There is some evidence, however, that the bulb yield is better when the treatment is done earlier than this so the bulb grower may choose an earlier date than would the flower producer.

Flower damage can be avoided and crop vigour improved by warming the bulbs before H.W.T. As this warm storage also increases the resistance of the eelworms to H.W.T. it is a mixed blessing but it is possible that before long we shall be able to settle for a process including a suitable balance of warm storage, pre-soaking and H.W.T. at a higher temperature which will control eelworm without damaging the flowers or the bulbs.

Much of the development in eelworm control has followed laboratory research. Special difficulties involved in experimentation with eelworm-infested bulbs in the field have often prevented us from getting equally consistent results but we can say that the trends in a number of field experiments are helping to confirm research results and we are getting further confirmation from results of larger scale application of treatments in the field.

We now know that eelworms can survive and breed on many host plants and thus the chances of any large commercial plantings remaining clean indefinitely without treatment are remote, and a routine treatment for stem eelworm control is likely to remain a feature of narcissus culture.

To avoid trouble the points to watch are:

1. Assume all new stocks are infested. Plant in isolation or give a very thorough H.W.T. if bulbs are received in time for this to be done.
2. Rogue the growing crop and remove infested plants and adjoining ones at once. Treat the adjoining ridge or rows with nematocide.
3. If eelworm has been found in a stock, lift it early and give it a thorough H.W.T.
4. Lift, apply H.W.T. and replant regularly; every two years if possible. Bulbs may be left down three years in exceptional cases but never longer.

It is unlikely that bulb eelworm will ever be entirely eliminated but it should be possible to get it down to such a low level that it is rarely seen.

L. W. Wallis

PROTECTING STRAWBERRIES BY POLYTHENE

Polythene has been available for several years in varying widths and producers of early strawberries quickly realized it might form a cheaper and more easily handled form of protection than the barn, or tent, type of glass cloche. Growers in southern England have tried several methods of supporting the polythene over the plants. Wide sheets of polythene on wire arches with criss-cross light tie wires were originally tried, but it was found that the polythene was easily torn, or displaced by winds and handling was a problem.

At present three main methods are in use:

1. Polythene tunnels covering a single, or closely planted double, row of plants using 40 to 42 in width.
2. Wider tunnels covering three or four rows using 48 to 60 in width.
3. Layflat polythene held down with battens and without wire hoops, generally 8 ft wide and covering 4 to 6 rows of plants.

Thin polythene of 150 gauge is used, but some experimental work elsewhere is being done with the more expensive but thicker PVC 800 gauge which transmits more light.

Efford Experimental Horticulture Station is doing experiments with polythene tunnels and layflat polythene comparing different varieties grown under these methods of covering with similar varieties under glass cloches.

The wire hoops for the polythene tunnel are made from 8 gauge wire and bent by means of home made jigs. Usually 9 in. is allowed in the soil, then a small circle is twisted, to allow for attachment of the tie wire, of 16 gauge, which holds down the polythene. The actual height and width of the hoop above ground depends on the size of plant expected. The tunnel should be kept as near the plant as possible but not to touch and damage flowers and fruit. Variety, size of runner, time of planting will all influence growth. Hoops are often about 12 in. high and 18 to 24 in. wide. The approximate cost per hoop is 7*d.* and they need to be used every 4 ft in order to keep the polythene stretched tightly, essential for success.

The polythene should be put over the plants at the normal time of cloching with glass. One big advantage is that it is comparatively easy to push up the polythene between the two hoops for access to the plants for spraying, watering, weeding and picking.

Layflat polythene is not so widely used as tunnels. The polythene is held right down to the plants by a system of 1 × 1 in. knot free continuous batten, around which the polythene is wrapped and stapled. Surplus poly-polythene is wrapped around one batten and the battens held down with 20 in. mild steel, shepherd's crook type pegs. As the soil warms underneath the polythene the plants grow and hold up the polythene with their leaves. When it becomes rather tight the polythene is loosened by unwrapping the battens. See Plate vi.

At Efford in 1965, single rows of plants under polythene tunnels were compared with exactly similarly treated plants under barn glass cloches. The fruit ripened, depending on variety, five to ten days later than the glass cloches and the yield was slightly less. Plants under layflat ripened earliest, some five to nine days before the glass cloches, but the yield was very much less, only one quarter to one fifth of that obtained from the plants protected by glass, the berry size was smaller and there was more malformed fruit.

The layflat process is essentially a forcing method. Air and soil temperatures taken at Efford show how the soil under the layflat warms up more quickly than under glass cloches, the tunnel being the coldest. The air temperatures were also highest under the enclosed layflat, which was not opened. There is some difference of opinion amongst experienced growers as to whether, by judicious opening of layflat and tunnels, better growing conditions could be obtained. It is a slow and expensive job to space glass cloches and this is generally not done until May, when frost danger is over. Sometimes glass cloches become very hot during warm spells in April and the plants suffer as soil moisture is often depleted. Layflat and tunnels kept closed at Efford retained soil moisture much more than glass cloches and also could be more easily watered. It has not yet been possible critically to compare polythene coverage kept closed with coverage, opened during hot days and closed in the early afternoon to trap the warmth from the soil. Growers are experimenting for themselves on this. Grey mould disease and *Botrytis* is surprisingly not too troublesome under coverage, but mildew can be a problem under very hot and dry conditions and protective sprays of dinocap are necessary.

All systems of protection demand a reasonably sheltered site. Wind can damage the polythene, tear it, or lift the hoops. Reports have been received of economically successful use of polythene from areas away from the traditional early areas in the south and south west of England. It is necessary to cover one-year-old plants generally planted the previous August to September. Cambridge Favourite, Redgauntlet, Cambridge Vigour and Cambridge Prizewinner have all done well at Efford.

Hilary M. Hughes

WATERING AND FEEDING OF TOMATOES

Growers of glasshouse crops have often asked themselves what quantities of water should be used in irrigation. Until 1956 they themselves or their advisers were not able to supply the necessary answer. Work in the early fifties at the N.I.A.E. demonstrated a close relationship between solar energy falling on a crop and the amount of water lost from its surface. With the installation of a solarimeter in a glasshouse at Fairfield Experimental Horticulture Station, a long term programme of investigation on the irrigation requirements of the tomato crop was started. The total energy from the sun on a horizontal surface was measured and the quantity of water it would evaporate was calculated. This will be the maximum quantity of water which could be used by a tomato crop at full ground cover. Tomato plants reach full ground cover at a height of 6 ft approximately. Drainage was measured by lysimeters and the difference found between the amount of water applied and that lost to the drainage system. During the course of six years experimentation it was shown that at full ground cover 67 per cent of the incident solar radiation was used for evapotranspiration during the months of April,

May, June, July and August. Before the crop has reached full ground cover a smaller amount of the solar energy is used for evaporating water. This phase of the tomato crop was also investigated at Fairfield and a graph was produced which showed the percentage which should be applied at various plant heights.

In recent years growers whose nurseries are near to Experimental Horticulture Stations have been provided with estimates of irrigation need obtained from solarimeter readings on the stations.

Also a cheap evaporimeter has been evolved at Fairfield in order that the grower may obtain figures more directly applicable to his holding.

During the period in which the quantities of irrigation water to apply were being investigated, the incorporation of soluble fertilizers in the applied water was also being studied. Using potassium nitrate, urea and Epsom salts, methods of making suitable liquid fertilizer concentrates were evolved. As a basis, we used the work of Dr. Owen of the former Cheshunt Research Station and our soil conditioner experiment which confirmed his findings. The weights of fertilizer required to supply a 60 ton tomato crop with nitrogen and potash (1200 K_2O and 600N) when applied in a seasons water gave a ratio of fertilizer to water of 1 in 1,000 by weight.

Using the solar radiation figures to calculate the water need and applying the 2:1 K_2O: N fertilizer at 1 part in a 1,000 parts of water by weight, heavy crops of tomatoes were obtained. However, the colour quality of the crop was generally poor. Although the salt concentration was high enough at the beginning of the season to give a pC of 2·9, continuous testing of the soil showed the salt-concentration was decreasing as the season progressed, when a 1:1,000 solution was applied. Under these conditions the final pC at the end of the season could be as high as 3·8.

Subsequently we doubled the amount of the fertilizer in the irrigation water to a level of one part of fertilizer in 500 parts of water by weight. We found that the pC value remained more or less constant at 2·9 throughout the season and that this increased soil solution strength resulted in very high quality uniformly coloured fruit. There was, however, an accompanying reduction in yield due to smaller fruit and the mis-setting of flowers.

The use of an intermediate concentration of fertilizer for watering (i.e., 1 part of fertilizer in 750 parts of water by weight) has led to a satisfactory yield, whilst allowing the production of fruit of good market quality.

Variations in the vigour of growth, fruit-yield and quality may be controlled by the grower by changing the dilution rate. Stronger solutions are employed to reduce growth and improve fruit quality, while weaker solutions are used to increase vigour and crop yield. In the ideal watering and feeding programme both watering and feeding should be completely controlled; for if the soil is not maintained at a standard water content (e.g., field capacity) drying out of the soil increases the concentration of the soil solution with similar effects to those experienced when feeds are too strong. These conditions of high salt concentration are responsible for poor growth, mis-setting, low crop yield and blossom end rot.

J. B. Rothwell

THE PREPARATION OF FLOWER BULBS FOR FORCING

The recommended treatment to prepare tulips and narcissus bulbs for forcing now embraces two phases:

(a) a high temperature treatment (for three to five days) immediately after lifting, followed by

(b) cool storage (usually at 48° F) for six weeks.

This second phase should not begin until the flower is fully formed within the bulbs.

Narcissus

The response of narcissus to storage treatments is more uniform than that of tulips and is less likely to be affected by soil and weather conditions before lifting and it has been easier to obtain a definite pattern of response to experimental treatments.

Lifting and warm storage

Lifting date has had very little effect on date of flowering but it may affect flower size. Early lifting before the petals are fully formed reduces the size of the flowers obtained during forcing.

The standard commercial preparation for narcissus bulbs for early forcing is to store at 93°F for three to five days, it has been found that this temperature was not critical, and that for Fortune and Golden Harvest, it can be increased to 95°F and held for five days. Stock bulbs of Fortune stored at 95°F for four days in 1965 were in full crop by 9 December and the flowers were making 4*s.* 9*d.* per dozen on the market.

Cool storage

Following the initial warm storage, standard practice is to put the bulbs into cool store for six weeks. The bulbs should be given a temperature of 63°F for one to two weeks to allow the flowers to develop fully within them before cool storage is commenced.

Cool storage brings the flowers earlier and shortens the period in the forcing house. The standard temperature used is 48°F. Though the length of this cool storage period was not critical, six weeks seemed to be the safest length. Golden Harvest stored at 48°F for eight weeks flowered earlier than bulbs stored for six weeks but the flowers were smaller and of poorer quality.

Soil temperatures after boxing

If cool stored bulbs are planted in warm soil when they are boxed, the effect of the cool storage is counteracted and flowering is retarded. Growers have been aware of this for many years and a straw covering kept moist by irrigation lines is used to keep the soil and bulbs cool after boxing. Experiments have shown that the optimum temperature for the soil after boxing, for good flower quality to be obtained is 48°F. A lower soil temperature (40°F) retards growth and therefore makes housing later but when the boxes are housed the flowers come on very quickly. Because of the rapid growth,

flower stalks tend to be weak and the flowers small. Higher soil temperatures (56°F) gave late, slow forcing in the house, but this was partly counteracted if the soil temperature was lowered to 40°F for the last six weeks before housing, though housing was retarded. High temperatures in the box, retarded the flowering date more in the variety Carlton than with Golden Harvest.

Tulips

Warm storage at lifting

Response to warm temperatures given immediately after lifting depends on variety and it has only been possible to carry out replicated experiments with a limited number of varieties. Rose Copland lifted on 8 July flowered a little earlier when given a week at 78°F than when given 63°F but when the bulbs were lifted at the end of July flowering was retarded. Paul Richter on the other hand showed a good response to a week at 93°F after lifting. The safe recommendation for all varieties is to store at 68°F until the flower formation has reached stage G, but some varieties will force earlier if given a week at 93°F or 78°F immediately after lifting. This is then followed by storage at 68°F until stage G is reached.

Cool storage

The normal 48°F for six weeks is used to forward forcing date but it cannot be used for all varieties, nor for any tulips which will not be housed before the beginning of February.

If the variety Elmus is cool stored, the flowers will be damaged. Damage to petals and stamens can occur if bulbs are put into cool store too early and the flower is late developing in Elmus. However, when Elmus bulbs were cool stored on 12 September, two weeks after stage G had been reached, forcing still produced feathery petals and aborted stamens. Date of cool storage does not appear to be the cause of the damage, rather the low temperature itself.

Late forcing of cool stored bulbs produces green tips to the petals and consequently only early tulips, to be forced in December and January, are cool stored.

Soil temperatures after boxing

Tulips are more sensitive than narcissus to soil temperatures after boxing; 48°F from boxing to housing is the safest temperature for most varieties since it produces the earliest flowers consistent with quality and percentage of flowers from the bulbs. A low temperature (40°F) delays housing and therefore flowering date, but the flowering period is then very short and as a result the percentage of small flowers is high.

When Golden Harvest bulbs were transferred from a temperature of 40°F to 56°F six weeks before housing, the mean flowering date was eleven days earlier than that for bulbs kept in 48°F all the time and the percentage of first grade flowers was much higher. The same treatment applied to Rose Copland, however, was disastrous, 38 per cent of the bulbs being blind.

Two great difficulties in bulb experimental work connected with the preparation of both narcissus and tulip for forcing are the effect of the

previous seasons growing conditions on the bulb development, and varietal differences in response. The effect of these two factors is greater with tulips than narcissus and must be taken into account when assessing the results of all storage experiments.

Elizabeth D. Turquand

EARLY CUT FLOWER CHRYSANTHEMUMS PRODUCED OUTDOORS

Approximately 1,000 acres of early flowering chrysantheums are grown in the open in England and Wales for cut flower production. When well grown and well marketed, the crop can be very profitable, but in recent years production and marketing costs have risen steadily while prices have remained at the same level. Experiments at the Lee Valley Experimental Horticulture Station have been designed to find ways of maintaining high profitability by increasing crop yield and cash return from the land and labour employed.

First the effects of propagation date, planting distance and shoot thinning were studied on three varieties, chosen to give a range of growth habits and flowering periods.

There were three propagation dates varying from year to year, between 22 February and 17 April. On each date the cuttings were rooted in seed trays containing J.I.P.1. Cuttings taken on the first two dates were lined out, when rooted, in cold frames. The cuttings taken on the third date were left in seed trays until planting time. As propagation dates varied from year to year, it was not possible to compare them accurately but blooms per plant were fewer as propagation was delayed. Up to the middle of March the decline was quite small, but after this time it became rapid. The labour requirement was greater for earlier propagation, as the plants required extra attention when held longer in the propagation section, and it was concluded that cuttings were best taken from early to mid-March.

Plants of each variety from each propagation date were set out in beds with five rows 9 in. apart but with different spacings between plants in the row (6, 12 and 18 in.). As the distance between the plants increased from 6 to 18 in. the number of marketable blooms *per plant* and the average size of the bloom increased, but at the same time there was a marked and progressive fall in the number of marketable blooms per sq. yd. This was reflected in the cash return per sq. yd, which was greatest at 9 in. × 6 in. in every year of the experiment.

Thinning of shoots to a fixed number per plant is sometimes done by growers and is known locally as 'counting down'. Half the plants were thinned ('counted down') to four shoots, the other plants were allowed to carry all the shoots they produced after stopping. The effect on yield was small, but in every year, shoot thinning reduced yield and cash return and increased the labour needed.

In the second part of the work, still in progress, the varieties have been increased to six, thus extending the range of growth habits and flowering times. All plants are propagated in the second week of March and the cuttings are lined out in cold frames as soon as they are rooted. There are two planting dates—28 April and 12 May.

Shoot thinning has again had only a small effect, but has again reduced yield and increased labour input. It must be concluded therefore that this practice has nothing to recommend it in cut flower production.

Planting date has also had only a small effect and there is evidence of an interaction with season. In 1964, the May planting gave the higher yield, while in 1965, the trend was for the April planting to do better. This confirms the belief of growers that the effect of planting date compared to that of propagation date is relatively small.

The closest spacing, 9 in. × 6 in., has again given the heaviest yield and greatest cash return per sq. yd in both years. In 1964, however, the increase in cash return at 9 in. × 6 in. compared with that at 9 in. × 9 in. was not sufficient to cover the extra production cost entailed. In 1965, 9 in. × 6 in. was marginally more profitable than 9 in. × 9 in. It would appear then, that 9 in. × 9 in. may well be close to the optimum spacing for general use, if land is to be used most profitably.

A standard system of production is thus emerging in which propagation in early to mid-March will be followed by lining out in cold frames as soon as the cuttings are rooted. Planting will be done as soon as the soil has warmed up, at some time between late April and the middle of May, and at a spacing 9 in. × 9 in. in the beds. The support nets will be placed over the beds as soon as planting has been completed. Experience has shown that the very expensive operation of staking and tying the plants individually is then unnecessary. The plants will be stopped once and all the shoots produced will be left to develop.

A. J. George

MUSHROOM CROPS GROWN IN TRAYS IN GLASSHOUSES

From 1961–64 experiments were conducted at the Lee Valley Experimental Horticulture Station to find the most economic techniques for growing mushrooms in trays in glasshouses. Each autumn and winter the three compartments of a heated glasshouse, which had grown tomatoes in summer, was used. The glasshouse was not insulated but was shaded with ordinary lime shading to reduce light intensity. Composting of the horse manure was done in the open and after filling the boxes they were stacked in a temporary structure of scaffolding and tarpaulins for peak heating. To maintain the required temperature for 44 to 65 hours, according to condition of the compost, live steam was injected via perforated fire hoses. After spawning,

the trays were placed in the glasshouse compartments for spawn running and growing-on. See Plate iii.

The effect of each treatment on mean yield over the four years are set out in the following Table:

Yield of mushrooms from two depths of tray grown at three temperatures by three spawning methods and with three rates of spawning (Weight of mushrooms in lb per sq. ft).

Treatment	Yield after 7 days		Yield after 8 weeks	
	6 in. trays	12 in. trays	6 in. trays	12 in. trays
Growing temperature				
54°F	1·4	2·7	2·1	3·7
60°F	1·6	2·9	2·3	4·2
66°F	1·8	3·2	2·4	4·4
Spawning method				
Super spawning	1·6	3·1	2·2	4·2
Surface „	1·5	2·6	2·2	3·7
Through „	1·7	3·2	2·3	4·4
Spawning rate				
½ oz/sq. ft	1·5	2·8	2·2	4·0
1 oz/sq. ft	1·6	3·0	2·2	4·1
2 oz/sq. ft	1·7	3·1	2·3	4·2
Mean	1·6	2·9	2·2	4·1

Temperature

Each year an increase in yield was obtained by raising the minimum growing temperature after casing above 54°F. The increment in yield from the 6 degree rise from 54°F to 60°F was greater than that from 60°F to 66°F. Accompanying this improvement in yield was an increase in the incidence of hard gill which was generally most severe in the 66°F regime and in the 6 in. deep boxes, which dried out more quickly at the higher temperatures. The most satisfactory growing temperature was 60°F, and at this level the mean yield of the 6 in. trays after seven weeks was increased by ¼ lb per sq. ft in comparison with 54°F.

Rate of spawning

Increasing the spawning rate from ½ oz of grain spawn per sq. ft to 2 oz per sq. ft gave small increases in yield. The greatest increase was obtained by raising the rate from ½ oz to 1 oz per sq. ft, whereas the extra 1 oz used when the rate was increased to 2 oz per sq. ft gave a smaller increment in yield and might not have covered the cost of the spawn. On occasion very high yields were obtained at the ½ oz rate but 1 oz per sq. ft was more consistent.

Spawning method

Three methods called 'surface', 'through' and 'super' spawning were compared. Grain spawn was used in each case. In surface spawning the spawn was ruffled into the surface of the compost. For 'through' spawning it was distributed by hand through the whole of the tray. In 'super' spawning one third of the trays to be used for growing were spawned first by 'through' spawning. In 14 days when the mycelium was growing actively the contents

of one tray were mixed with that of two unspawned trays to give three trays of 'super' spawned compost. With 6 in. deep trays the mean yields over the four years were very similar from the three methods tried, i.e., 'surface', 'through' and 'super' spawning. In 12 in. deep trays 'through' and 'super' spawning gave similar results, whereas 'surface' spawning gave a lower early and total yield. 'super' spawning generally gave heavier early yields but 'through' spawning quickly caught up to produce the same total yield. Success with 'surface' spawning appeared to be dependent on the quality of the compost and the rate at which the mycelium occupied the growing medium. In 1964, the 'surface' spawning method cropped slightly better than the 'through' spawned trays, but in 1963, when the compost was of poorer quality, the yields were considerably lower than with the other two methods.

Thus 'through' spawning was more consistent than 'surface' spawning and was preferable to 'super' spawning, which gave very comparable mean yields but had a higher labour requirement.

Depth of tray

Two depths of tray, i.e., 6 in. and 12 in., were used and in three out of the four years the highest yield per unit weight of compost was obtained from the shallower trays. The increase in total yield from the 12 in. boxes, which contained twice the weight of compost in the 6 in. boxes, ranged from 66 per cent in 1963 to 104 per cent in 1962. Over the four years, the mean increase was 85 per cent. The relationship in cropping between the two depths of trays was established during the first six weeks, and a similar pattern of yield was obtained during the remainder of the cropping period.

The trays were so arranged that two 6 in. trays occupied the same glasshouse space as one 12 in. tray and if it is assumed that an average gross return of 3*s.* 0*d.* per pound was obtained for the mushrooms, then the mean gross return from 12 in. trays spawned at a rate of one ounce per sq. ft would have been 8*s.* 11*d.* per sq. ft at seven weeks and 12*s.* 5*d.* at twelve weeks. Returns from an equivalent quantity of compost in 6 in. trays would have been 9*s.* 5*d.* and 13*s.* 3*d.* Compost in 6 in. trays has double the surface area of an equivalent quantity in 12 in. trays and thus the 6 in. trays take twice the quantity of spawn and casing material for the same amount of compost. This would have cost an additional 8*d.* per sq. ft and, after deducting this cost, the equivalent returns from each depth of box are very similar for the seven and twelve week periods. The deeper trays have the disadvantage of being very heavy to move unless mechanical handling equipment is available, but they would be relatively cheaper to purchase. In these experiments the 12 in. trays had 12 in. of air space but it is possible that 8 in. of space would be adequate, and then a greater quantity of compost could be accommodated in a given space if air conditions in the growing house permitted.

This experiment, conducted over four years, shows that the best combination of treatments would be 6 in. trays (unless mechanical handling equipment is available) with the compost 'through' spawned at the rate of 1 oz per sq. ft and grown at a minimum temperature of 60°F after casing.

P. G. Allen

New Items of Interest in the Experimental Programme

THE ARTHUR RICKWOOD EXPERIMENTAL HUSBANDRY FARM

Since its inception, the N.A.A.S. has been conducting experiments on commercial holdings in the black fens, following a long series carried out by Cambridge University. Even so, there are many problems which it has not been possible to cover adequately. The main one is, of course, the rapid wastage of the overlying peat and the best methods of farming the land as more and more of the underlying mineral matter has to be incorporated. However, an opportunity to investigate these subjects was provided by the late Alderman A. S. Rickwood, C.B.E., who generously donated his Paradise Farm, Mepal, near Ely, to the Ministry in December 1963.

This was established as the Arthur Rickwood E.H.F. at Michaelmas 1964, and comprises two distinct but adjacent parcels of 100 and 50 acres of black peat soils of varying characteristics. They range in depth from 48 in. to 15 in. and the underlying material is typical blue buttery clay under the greater part of the 100 acre block, while the 50 acres are fairly shallow peat over gravel. There was only a single cottage on the land, so farm buildings, office block, cottages, roads and other facilities are being provided and, as there is a main drain adjacent to both blocks of land, irrigation by portable equipment will be possible. The farm will be cropped on a typical fenland system with the emphasis on cash root crops, including potatoes, sugar beet, carrots and a number of vegetables such as celery and onions, together with cereals. Other crops may be introduced from time to time as the experimental programme demands.

The investigational programme will comprise basic projects. The study of the peat soil in all its aspects will be a most important feature. This will include experiments on its wastage, methods of incorporating the underlying mineral matter, moisture relationships and special points such as the use of herbicides in highly organic soils. Another main group of experiments will include all aspects of the husbandry of the crops in the area, including such questions as storage and preparation for market. The remaining areas, which are being cropped more or less on a commercial scale, will be used for studies such as labour organization and machinery utilization, and to provide material for the storage experiments.

LEVEL OF CONCENTRATE FEEDING FOR DAIRY COWS

The level of feeding in one part of a cow's lactation may exert a considerable influence on her milk production at a later stage. An example of this is the practice of steaming-up cows prior to calving in order to increase subsequent yields. Recent work at the National Institute for Research in Dairying has shown that a higher level of feeding may also be justified during early lactation itself.

In order to extend these results, a new experiment has been started at

Great House, Bridget's and Trawscoed Experimental Husbandry Farms (with Boxworth E.H.F. to begin in 1966). The object is to study the effects of high levels of concentrate feeding on the milk yields and live weights of cows and heifers during early lactation, and to determine the extent of any carry-over effects in mid- and late-lactation.

During the first 10 weeks of lactation, 15, 20, or 25 lb. of concentrates will be fed daily to cows. During the next eight weeks, 15 or 20 lb will be fed, giving six combinations of early and mid-lactation feeding rates. A further group of cows will be rationed conventionally according to yield. The experiment will thus compare yields resulting from weekly adjustments to the feeding rate, with those from flat rate feeding imposed without reference to individual yields. With heifers, all the feeding rates will be reduced by 4 lb, otherwise the comparison will be similar. After the eighteenth week of lactation, all animals will be put on standard concentrate feeding, regulated according to yield. A basal fodder ration of constant quality and quantity will be fed in addition to the concentrates during the winter and the cows will graze together during the summer.

The first four weeks of the succeeding lactation will be used to measure any residual effect of the treatments, and the experiment will be continued until approximately 180 cows or heifers have been tested.

NITROGEN AND STOCKING RATE FOR BEEF CATTLE GRAZING

Where grassland is grazed by beef cattle the rate of application of fertilizer nitrogen and the number of beasts stocked per acre are two factors which have a big influence on the level of output. To learn more of the relationships between these factors and liveweight gain per beast and per acre, a co-ordinated trial commenced in the spring of 1965 at High Mowthorpe, Rosemaund and Trawscoed Experimental Husbandry Farms; valuable advice concerning its conduct having been obtained from members of the staff of the Grassland Research Institute.

On each farm a ley receives three levels of nitrogen—50 units, 175 units and 300 units per acre, and at each level young beef cattle are rotationally grazed at three pre-determined stocking rates. Records taken include the weight of all surplus herbage removed for conservation, and the fasted weight of each grazing animal at the commencement and at the completion of the grazing season. Health records of the stock are kept and also post-grazing records of beasts not slaughtered off grass. The botanical composition of all swards is to be checked annually.

In 1965, the first grazing season of this trial, a total application of 175 units N per acre was always economically sound, and an increase to 300 units was valid in some circumstances.

The rate of individual liveweight gain almost always declined with each increase in stocking rate within any level of nitrogen application. Total liveweight gain per acre was increased by all rises in stocking rate up to three beasts per acre at Rosemaund and at High Mowthorpe and up to two beasts per acre at Trawscoed, where the grazing animals used were older. Above these levels of stocking liveweight gain per acre declined, apparently

because excessive soiling of the herbage reduced its palatability from mid-season onwards.

FAT LAMB PRODUCTION FROM GRASSLAND RECEIVING DIFFERENT LEVELS OF NITROGEN

Intensification is a word which has become almost inseparable from farming at the present time. The days of 'dog and stick' farming on the lowland farms in this country have gone. No longer can a decent living be made from even 2½ ewes to the acre, if realistic values are put on rents and other costs. Many farmers seeking a substitute for milk production, with its attendant drudgery, have been turning to sheep. However, at present there is little critical information on the limits of stocking rate and level of nitrogen that can be used on grassland grazed by sheep on an all-the-year round farm scale.

With intensification has come specialization—milk being produced by specialists, specialist pig and poultry farmers, and so on. Increasing numbers of farmers with a number of enterprises have abandoned the less profitable or less pleasant of these to become specialists themselves in one or perhaps two lines.

With this background in mind an experiment is to begin in 1966, probably at three Experimental Husbandry Farms: Drayton, Rosemaund and Trawscoed. This experiment is of the farm unit type*, the basic unit simulating an all-grass farm stocked entirely with sheep. The object is to produce fat lamb from grass. There are nine farm units in the experiment at each centre and the main comparison is between three levels of nitrogen fertilizer, each coupled with an appropriate stocking rate. To remove to a large extent the subjective element in choice of an appropriate stocking rate there are three stocking rates at each level of nitrogen. Hence, three levels of nitrogen × three stocking rates = nine comparisons (and nine farm units).

The levels of nitrogen are nil, 120 units and 240 units per acre per year. The stocking rates range from 2½ ewes per acre (true annual stocking rate) to over 6 ewes per acre. On each of the Experimental Farms concerned there will be well over 200 ewes tied up in the experiment for the next five years or so. Also, about 70 acres of each farm will be taken up for the same period.

In addition to studying the managerial problems involved and obtaining accurate input and output data this experiment will provide an excellent opportunity to study many parasitic and other health problems. To this end, the farms will maintain close co-operation with their veterinary practitioners and with the Veterinary Investigation Service of the Ministry.

NON-PROTEIN NITROGEN AND STRAW FEEDING TO CATTLE

In certain extensive farming areas, such as parts of South Africa, where arid climates give only poor pastures at best, it has been found that the

*See article on pages 6 to 15.

performance of cattle on low quality fibrous grazing has been improved by allowing them to consume limited quantities of urea contained in licks (blocks) or self-help liquid supplements. The explanation of this is that urea is a cheap source of the nitrogen needed by the rumen bacteria that break fibre down to energy-foods utilizable by cattle. For some years such supplements containing urea, minerals and an energy-food (such as cereals) have been used by farmers in this country for the same purpose, i.e., in order to utilize poor pasture or low quality roughages, such as poor hay or straw. In the hill areas and mountain farms in particular, where hand feeding is often impossible or an unsatisfactory method under extensive grazing, and the soil, climate and topography determine that pasture quality will be poor. Self-feeding blocks of such supplements could well have a significant effect on production (see page 45 of this publication for a description of work on feeding hill sheep in this way). It may also be useful in aspects of lowland cattle farming where high performance per animal may not be necessary, such as in the rearing of dairy heifer replacements. However, where high outputs per acre are needed, particularly on high value land capable of growing good grass or profitable cash crops, this system is less likely to be appropriate.

In this situation, in order to achieve a high output of saleable product per acre, quick liveweight gains by fattening animals and high milk yields from dairy cows are needed. These will not be given by diets solely consisting of poor roughages and non-protein nitrogen, as the energy requirements of these classes of stock can only be satisfied by diets of high digestibility and energy value, i.e., high quality grazing and roughages and starchy concentrates in appropriate proportions. However, straw-feeding may have a place on cereal/grass farms as a cheap source of roughage to be fed as a limited proportion of winter rations in which most of the energy and protein is provided by concentrates. The profitability of this would depend upon how far it will enable farmers to devote less of their grass acreage to the expensive process of conservation and more to grazing, giving higher all-the-year-round stocking rates and saleable output per acre. Non-protein nitrogen may also have a place in cheapening concentrates generally, because on a crude protein basis it is cheaper than fish meal or oil cakes. However, urea is liable to be toxic to animals if it is included in concentrates at too high a rate. These aspects are being or are about to be investigated on the husbandry farms.

Straw Feeding

At Trawscoed during the winter of 1964–65, store cattle were outwintered on *ad lib* oat straw. One group was given a concentrate supplement while another had free access to blocks containing urea. During the winter of 1965–66, using similar cattle, comparisons are being made between supplementing straw with concentrates alone or with concentrates plus urea in liquid form. At High Mowthorpe, beef from a February calving single-suckler herd is to be studied, starting in the spring of 1966. Winter feeding of the cows is to be based on the results of trials on *ad lib* barley straw and limited barley feeding in progress at the Rowett Research Institute. Further supplementation with non-protein nitrogen may also be studied in this context. At Bridget's a study is being made of feeding milking cows on straw with concentrates containing normal protein. A trial is in progress

during winter 1965–66, comparing performance on three feeding systems; high quality silage *ad lib* with minimum concentrates; a limited ration of the same silage eked-out with barley straw, with concentrates fed accordingly; and straw as the only roughage, supplemented by a high rate of concentrate feeding.

Urea Instead of Protein

At High Mowthorpe during the winter 1965–66 spring born calves are being finished in yards at about one year old, after being reared at grass. They are being fed silage, hay and *ad lib* barley-based concentrates. A comparison is being made between types of concentrates, including one consisting of barley, 1½ per cent urea and minerals only. At Rosemaund, a group of beef cattle are being finished on silage, hay and similar cereal, urea and mineral rations. At Great House during the winter of 1965–66 a trial has been completed on milking cows fed silage and hay for maintenance and concentrates at 4 lb per gallon. A normal concentrate has been compared with one in which urea has been included at ½ per cent of the mix, to give 1½ per cent crude protein in the total of 13½ per cent. At Boxworth, Bridget's and Trawscoed groups of milking cows are being fed with concentrates containing 1 per cent of urea at 4 lb per gallon for all yields or over 1½ gallons. Depending upon the results of these studies, a further trials programme may be started in winter 1966–67. One of the subjects to be studied might be the possibility of including urea in the concentrates at rates higher than 1 per cent, when they are fed in relatively small quantities in high-roughage rations.

EVALUATION OF THE METABOLIZABLE ENERGY SYSTEM OF RATIONING FOR RUMINANTS

Early in 1966 the Agricultural Research Council published a Technical Review outlining a new system of calculating rations for ruminants based on metabolizable energy. It was suggested in the foreword that this system should gradually replace the existing starch equivalent system. Before any such new system can be put into practice by advisers in the N.A.A.S., there must obviously be a period of trial and comparison between the starch equivalent system which has served as a basis for advice on rations for ruminants for some sixty years, and the new proposals. These are based firmly on the very considerable amount of fundamental research which has been done during the last twenty to thirty years on the energy metabolism of the ruminant. Discoveries have been made which highlight weaknesses in the basis of the starch equivalent system in use at present.

Any rationing system used for practical advisory purposes, is subject to a number of errors. These include inaccurate estimates of the quantities of feed eaten and the difficulties of estimating the feeding value of forages which vary, particularly hay and silage. Because of these uncertainties, which apply to advisory work and experiments on commercial farms, it is not likely that much information of value can be obtained by comparing the two rationing systems under these conditions. The first essential is accurate measurement of all food intakes, measurement of all production, whether it be in terms of liveweight gain or milk, and as accurate as possible an

evaluation of all the feeds being fed. This situation does in fact obtain on the N.A.A.S. Experimental Husbandry Farms, where accurate measurements are made in the course of a great many livestock experiments carried out each year. These Farms, therefore, offer a unique opportunity to test out the relative merits of the two feeding systems. It has been accepted that, without laying down any special trials for the purpose at this stage, many of the experiments currently running on both beef cattle and dairy cows, can be used for this. The degree of agreement between what in fact happens and what the systems predict ought to have happened can be checked, and the two systems compared over a considerable number of animals on a variety of different rations.

Metabolizable energy is the energy value of the food finally available to the animal for body maintenance and production, after wastages through dung, urine, and fermentation in the rumen. It is fortunate that in order to place a metabolizable energy value upon a feed, all that needs to be known with a fair degree of accuracy is its digestibility, i.e., the proportion actually absorbed by the animal, as opposed to passed out in the dung. This is because urine and methane losses are a fairly constant proportion of the digested energy. These farms carry out digestibility trials with sheep on the fodders used in their experiments, so the metabolizable energy calculations can easily be made.

It will be readily understood that this study will involve a considerable amount of computation and it was decided at an early stage that this should be done with the help of the computer at Rothamsted, which handles all the experimental data from the Experimental Husbandry Farms. It also seemed necessary to arrange for fairly easy retrieval of information as required without involving staff in writing out the results again. With this in mind, punched cards have been designed with appropriate codings, so that all the data from experiments on both beef cattle and dairy cows can be recorded in this manner and fed into the computer. A special programme will have to be written on the computer for this purpose but it does mean that the task of comparing these two systems systematically over a number of experiments and a large number of animals can be undertaken in a reasonably short space of time because of the huge capacity of the computer to carry out calculations of this type.

It is hoped that in time it will become clear what the relative merits of the two systems are and what the advantages might be of using the one or the other in various circumstances. In addition, the investigation will provide a great deal of information with which to evolve the necessary practical form of the feeding system for use in the field.

MUTSU—A NEW APPLE CULTIVAR

Mutsu is a Japanese apple which has attracted considerable attention at the National Fruit Trials in recent years as a possible late green fruited cultivar which could supplement the supply of Cox's Orange Pippin. It was raised at the Aomori Experiment Station in 1930 from a cross between Golden Delicious and Indo, and was introduced in 1952. It has the merits of being a regular and heavy cropper producing a high percentage of its fruit of at least $2\frac{1}{2}$ in. and storing well.

The apple is green changing to yellow with an occasional orange brown flush and is usually at its best when beginning to change colour. At this stage the flesh is crisp, juicy and pleasantly flavoured. The shape is oblong narrowing towards the eye with slight ribbing towards the apex. The stalk is rather long. It is a useful cultivar to spread the picking season, being usually ready to pick about ten days to a fortnight after Cox's Orange Pippin. The natural storage season is November to January and it can be cold stored until the end of March.

Mutsu makes a very vigorous tree rather spreading in habit with wide angled crotches associated with triploids. Flower buds are borne both on spurs and terminally, and the growth and bearing habits make the tree suitable for regulated pruning. The flowering period is about the same time as Cox's Orange Pippin, but as Mutsu is a triploid it is of little use as a pollinator. It is essential to ensure that it is cross pollinated and for this purpose James Grieve is recommended, or alternatively a combination of James Grieve and Cox's Orange Pippin. See also Plate v.

LATE CROPS OF CELERY

The growing of a late crop of celery has been under investigation at Rosewarne Experimental Horticulture Station for the past three years. Provided the crop was not damaged by severe frost, which is a rare occurrence in this area, a satisfactory crop could be produced for either processing or sale for direct consumption from planting in late June or early July. Later planting than this produced small sticks which were of insufficient size after trimming. The plants were spaced 7 in. apart in rows 5 ft apart and provided the earthing up was delayed until after Christmas the celery remained in good condition until late February or early March. Of the varieties tried Fenlandia proved to be the most resistant to pithiness and the most satisfactory for this crop. Several applications of slug pellets were given during the growing season and the number of sticks showing slug damage was rarely more than 6 per cent.

Part of the crop was sent for processing and part was sold as fresh celery.

Leaf spot (*Septoria apii-graveolentis*) did not occur when the seed had been carefully treated with warm water; this is essential in a high rainfall and humidity area such as Cornwall.

KALENCHOE: A CHRISTMAS POT PLANT

Robert Blossfield, a German nurseryman pioneered the development of the Kalanchoe as a commercial pot plant some 40 years ago, and although it has been grown in this country for a considerable time, it is only in recent years that it has gained in popularity, being now offered for sale in most florist's shops. The plant is compact, with dark green shiny leaves and bears numerous heads of small, brilliantly coloured, star shaped flowers, usually a shade of red, but varieties can be obtained having yellow or orange tints.

It can be propagated from seed or cuttings and its attractiveness to the nurseryman lies in the fact that the time of flowering is influenced by both daylength and temperature, making it possible to 'time' the crop accurately

for specific markets, in particular Christmas, but batches are also sold in autumn and early spring.

The Kalanchoe is a 'short-day plant' meaning that in the long days of late spring and summer it forms leaves and stems, and only when day-length is at minimum in mid-December are flower buds initiated, the plant flowering naturally the following spring.

Work at Fairfield over the last three or four years has examined first by the purely cultural side of this crop and secondly these environmental effects. Various levels of air temperature have been tested, and the maintenance of a minimum of 60°F seems to be essential, plants grown at 54°F have a longer development period and do not finish up as a robust or high quality product (See Plate viii). Short days are given 'artificially' in order to forward flowering, by covering batches of plants with black cloth or polythene from 4.30 p.m. to 8 a.m. giving an $8\frac{1}{2}$ hr day for 24 consecutive days, and the Fairfield staff have demonstrated that a 'short-day' treatment period from 7–31 August accurately times this plant for the Christmas market when grown at 60°F.

On the cultural side, the $4\frac{1}{2}$ in. dwarf plastic pot has been found very satisfactory, as this nicely balances the rather squat habit of the plant. Various composts can be used, but one of good 'holding' value (i.e., high nutrient level) should be selected as the plants are in the pots usually from June/July until November/December.

This is a first class pot plant for the housewife as it should last in flower at least six weeks without any undue fading or deterioration under normal home conditions, but the nurseryman must realize that it is important to market the plants when in full flower as it has been found that checks in growth due to poor light and low temperatures in some dwellings induce colour fading in any half opened buds and completely prevent tight buds from opening at all.

Experimental Husbandry Farms and Horticultural Stations

Centre	*Acreage*	*Main Farming and Experimental Activities*
		HUSBANDRY FARMS
Arthur Rickwood E.H.F. Mepal, Ely, Cambs.	150	Intensive arable farm on black fen peat. Fen wastage studies; cereals, root crops: and some horticultural crops of the area.
Boxworth E.H.F. Boxworth, Cambs.	858	Mixed farm on boulder clay. Friesian cattle. Rearing and feeding dairy stock; cereal husbandry.
Bridget's E.H.F. Martyr Worthy Winchester, Hants.	1,035	Large-scale arable farm with leys on chalk. Ayshire and Friesian herd and cross-bred ewes. Management and feeding of dairy stock; growing cereal crops, growth of leys and conservation.
Drayton E.H.F. Alcester Road Stratford-on-Avon Warwickshire	469	Mixed farm on Lias clay. Beef cattle feeding; cross-bred ewes. Utilization of grassland for beef and lamb production; grass conservation.
Gleadthorpe E.H.F. Welbeck Colliery Village Mansfield, Notts.	493	Light sand arable farm. Rearing Friesian steers. Poultry. Production of arable crops; irrigation; maintenance of fertility; feeding and management of laying poultry.
Great House E.H.F. Helmshore Rossendale, Lancs.	460	High lying Pennine farm in industrial area. Ayshire cattle, Derbyshire Gritstone sheep, Large White pigs; poultry; management of dairy cattle. Production, utilization and conservation of grass. Rearing and housing of laying hens.
High Mowthorpe E.H.F. Duggleby Malton, Yorks.	1,080	Arable farm on high lying chalk. Cross-bred beef cattle; cross-bred ewes; Large White pigs. Production of cereal and root crops; rearing and feeding of cattle and sheep.

Centre	*Acreage*	*Main Farming and Experimental Activities*
Terrington E.H.F. Terrington St. Clement King's Lynn, Norfolk	311	Large White and Essex pigs. Production of arable crops, including cereals, potatoes, sugar beet, soft fruit, and tomatoes under glass. Pig breeding and management.
Liscombe E.H.F. Dulverton, Somerset	495	Upland grass farm adjoining Exmoor. North Devon and cross-bred cattle; Clun, Welsh and cross-bred sheep. Breeding and rearing of cattle and lambs. Production and utilization of grass and fodder crops.
Pwllpeiran E.H.F. Cwmystwyth Aberystwyth, Cards.	3,100	Welsh mountain farm. Welsh sheep and Welsh Black cattle. Management of cattle and sheep; provision of winter fodder; shelter.
Rosemaund E.H.F. Preston Wynne Hereford	437	Mixed farm on heavy red sandstone soil. Hereford and cross-bred cattle, cross-bred sheep. Breeding and management of beef and beef × dairy cattle. Production of arable crops and hops.
Trawscoed E.H.F. Trawscoed Aberystwyth, Cards.	808	Mixed farm on shale-type soils with moor. Freisian cattle and a Hereford suckler herd. Welsh and half-bred sheep; Large White pigs. Rearing and feeding dairy stock; growth and utilization of leys; breeding and management of sheep and pigs.

HORTICULTURE STATIONS

Cleppa Park E.H.S. Cardiff Road, Newport Monmouthshire	68	Production of fruit, vegetable and flower crops under local conditions in the open, under Dutch lights and cloches, and in glasshouses.
Efford E.H.S. Lymington, Hants.	376	Nutrition and variety trials with top and soft fruit; vegetables including potatoes; tomatoes and other crops in heated and cool glasshouses; flower crops; irrigation.
Fairfield E.H.S. Greenhalgh, Kirkham Preston, Lancs.	22	Glasshouse crops including tomatoes, lettuce and flowers; mushrooms; blackcurrants and raspberries.

Centre	*Acreage*	*Main Farming and Experimental Activities*
Kirton E.H.S. Boston, Lincs.	104	Bulb production and forcing. Vegetable variety testing.
Lee Valley E.H.S. Ware Road Hoddesdon, Herts.	26	Glasshouse crops including tomatoes, cucumbers, lettuce, chrysanthemums; flowers in the open; mushrooms; mobile glasshouses.
Luddington E.H.S. Stratford-on-Avon Warwickshire	230	Apples, plums and soft fruit, pest and disease control, nutrition and root-stocks; vegetables and flowers; mobile glasshouses; irrigation; weed control.
Rosewarne E.H.S. Camborne, Cornwall	109	Early bulb and vegetable crops including potatoes; mobile glasshouses; shelter. Bulb conditioning and flower storage.
Ellbridge E.H.S. (Sub-Station) Hatt, Saltash, Cornwall	5	The study of early crops produced in the Tamar Valley.
Stockbridge House E.H.S. Cawood, Selby, Yorks.	161	Vegetable crops including rhubarb. Top and soft fruit; fixed and mobile structures; shelter; mushrooms; flowers.
National Fruit Trials, Brogdale Farm, Faversham, Kent	185	Testing and classification of all types of top and soft fruit.

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N·A·A·S EXPERIMENTAL FARMS & STATIONS

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